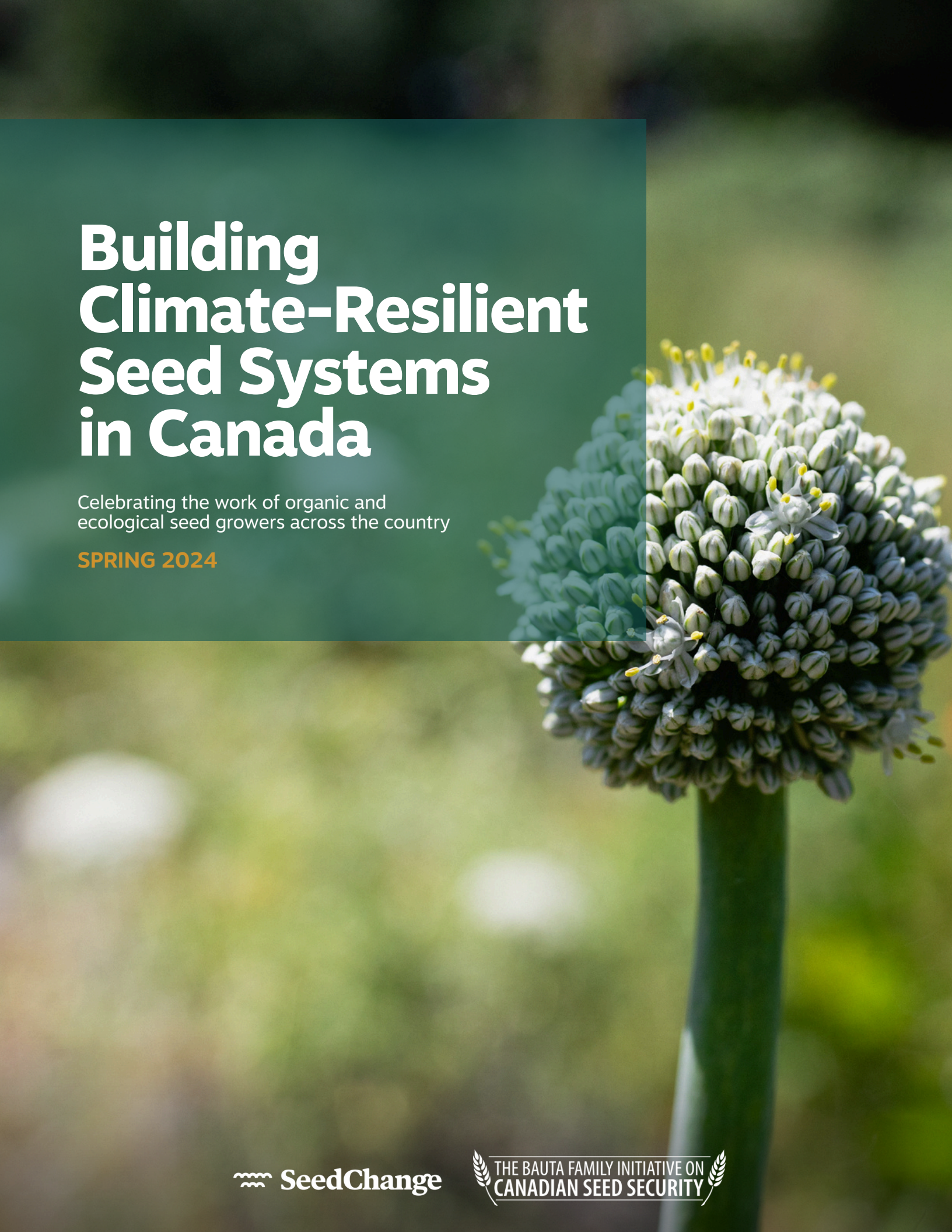

Building Climate-Resilient Seed Systems in Canada

Celebrating the work of organic and ecological seed growers across the country

SPRING 2024

SeedChange

THE BAUTA FAMILY INITIATIVE ON CANADIAN SEED SECURITY

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Cover Image: Onion plant starting to bloom at Abbotsford Research and Seed Education Farm in British Columbia.

Photo credit: FarmFolk CityFolk.

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Acknowledgements

The Bauta Family Initiative on Canadian Seed Security, a program of SeedChange, is building a movement for resilient seed systems across Canada. Our program works with farmers and seed savers who employ organic, ecological, and climate-resilient farming practices and are interested in increasing the quality, quantity, and diversity of regionally grown seed adapted for Canada's diverse growing regions.

The Bauta Initiative works with over 200 farmers to implement participatory on-farm seed conservation, variety improvement, and plant breeding programs. These programs are complemented by extensive knowledge transfer activities and farmer-to-farmer learning opportunities for farmers through our core partners:

- Seeds of Diversity Canada (National): seeds.ca
- FarmFolk CityFolk (British Columbia): farmfolkcityfolk.ca
- Organic Alberta (Prairies): organicalberta.org
- Ecological Farmers Association of Ontario (Ontario): efao.ca
- Sème l'avenir Québec - SeedChange Quebec (Québec): onsemelavenir.org
- Atlantic Canadian Organic Regional Network (Atlantic Canada): acornorganic.org

This report presents the highlights of the "Growth Opportunities for Canadian-Grown Organic and Climate-Resilient Seed in Canada" project. This project is funded in part by the Government of Canada through Agriculture and Agri-Food Canada's Canadian Agricultural Strategic Priorities Program (CASPP).

This project was implemented in partnership with the core regional partners of the Bauta Initiative, and the amazing network of farmers, seed growers, and research institutions we have the privilege of working with. For a full list of all of the farmers and partners that contributed to this project, please see **Appendix A**. For a full list of seed growers contributing to the full diversity of seed being grown in Canada, please visit **weseedchange.org/local-seeds**.

We also want to acknowledge that farmers, seed savers, and Indigenous seedkeepers have been saving and developing seed varieties long before the start of the Bauta Family Initiative on Canadian Seed Security, and will continue to do so long after. The crop diversity we all benefit from today is a result of their seed stewardship.

We thank those who have laid the foundation for our work, through their passionate saving and sharing of seed, and building of community. We hope that our work supports yours and enables more farmers and communities to contribute to the seed movement in Canada.

In partnership with:

EFAO Ecological Farmers Association of Ontario

FarmFolk CityFolk

organic Alberta

Seeds of Diversity / Semences du Patrimoine

national farmers union / union nationale des fermiers

CANOVI Canadian Organic Vegetable Improvement
ALÉBIO Amélioration des légumes biologiques au Canada

ACORN Atlantic Canadian Organic Regional Network

Organic Seed Alliance

UBC FARM Centre for Sustainable Food Systems

University of Manitoba

With national support from:

Agriculture and Agri-Food Canada / Agriculture et Agroalimentaire Canada

Canada

Weston Family Foundation

Fondation ECHO Foundation

Highlights

Seeds are the foundation of agriculture, and seed diversity is critical to the success of climate-resilient farming systems.

Preserving, improving, and developing seed diversity for organic, ecological, and climate-resilient farming systems offer promising solutions, not only in helping farmers reduce greenhouse gas emissions, but also in providing ecological benefits and building resilience to changing climatic conditions. To demonstrate the potential of this work being led by farmers, seed growers, and researchers across the country, SeedChange launched the "Growth Opportunities for Canadian-Grown Organic and Climate-Resilient Seed in Canada" project in partnership with Agriculture and Agri-food Canada.

- This project established demonstration gardens across Canada **to showcase, share knowledge about, and evaluate regional seed varieties of vegetables and field crops.** These sites connect the agricultural community and the public in order to foster awareness of regional seeds for climate-resilient farming systems, and ultimately support their increased spread, adoption, and commercialization.

- **24 demonstration sites were established at farms and research institutions across the country from 2021–2023**, showcasing and evaluating hundreds of different regional seed varieties. Demonstration sites highlighted two groups of crops: vegetables and field crops. Vegetable sites showcased regional open-pollinated (OP) varieties and field crop sites highlighted farmer-bred varieties, heritage/heirloom grains, and varieties of wheat and oats developed through participatory plant breeding (PPB) programs.

- Our team hosted **45 educational opportunities**, engaging over **1,100 participants across the country** about the value of regional seed. We also surveyed **146 farmers and seed growers** to assess the degree to which they have experienced changes in their seed saving skills and access to seed diversity through participating in this project and other related activities of the Bauta Family Initiative on Canadian Seed Security:

    - **83.7%** improved their abilities related to organizing and implementing variety trials.
    - **74.4%** improved their abilities related to plant selection, variety improvement and/or on-farm plant breeding
    - **66.4%** were saving a greater diversity of vegetable or field crop seed.
    - **60.2%** were purchasing more regional seed

- The diversity of varieties being adapted and developed by organic and ecological farmers, and the engagement of the farmers and researchers to learn about the work of this community are positive signs of growth and momentum in this sector. However, **there remains a significant opportunity for federal investment in this area** to not only help the growth of the organic, ecological, and climate-resilient farming sector grow, but to help Canada meet multiple public policy commitments while strengthening the resilience of Canadian agriculture as a whole.

Ultimately, as more farmers adopt climate-resilient farming practices, having access to a diversity of regional seed produced for those conditions will be critical to move Canadian agriculture towards a more sustainable and climate-resilient future.

Summer squash being hand-pollinated at Patchwork Farms in Quebec. *Photo credit: Parafilms.*

Glossary

This report will use terminology that will be very familiar to farmers, seed growers, plant breeders, and other agricultural stakeholders, but each of these groups may interpret these terms differently. This glossary defines how these terms are used in this report.

ORGANIC/CERTIFIED ORGANIC:
Agricultural systems that place strict limits/prohibitions on the use of synthetic fertilizers, agrochemicals (i.e. pesticides, herbicides, fungicides), antibiotics and synthetic hormones, and genetically modified organisms (GMOs). The Canadian Organic Standards oversee the certification status for agricultural products produced under these standards.

ECOLOGICAL:
Agricultural systems that use organic practices, but may not choose to be certified organic; similar to organic producers, ecological producers prioritize agricultural practices that promote biodiversity, soil health, and regional food sovereignty, while also limiting/prohibiting the use of synthetic fertilizer and agrochemicals.

REGENERATIVE:
Agricultural systems that focus on recovering and enhancing ecosystems alongside agricultural production through minimal tillage, rotational grazing, and improving soil health. No certification exists for regenerative agriculture; however, "regenerative organic" is a certification status through the Regenerative Organic Alliance in Canada.

REGIONALLY-ADAPTED:
Crop varieties that have been adapted to perform well in specific regional environmental conditions.

REGIONALLY-BRED:
Crop varieties bred to perform well in specific regional environmental conditions.

REGIONAL SEED:
Seed that has either been regionally-bred, regionally-adapted, or regionally-produced under organic or climate-resilient farming conditions.

OPEN-POLLINATED (OP):
Varieties that are pollinated through natural mechanisms (i.e. self, wind, insects) and produce true-to-type seed (i.e. the same characteristics as its parents) every generation.

HYBRID (F1):
Varieties that are developed when crossing two non-identical inbred parent lines; the progeny from hybrid varieties will not produce true-to-type seed.

PARTICIPATORY PLANT BREEDING (PPB):
A breeding approach where farmers and plant breeders work together to produce varieties guided by the expertise of both parties; this often involves plant breeders making crosses to create new breeding lines and farmers selecting and evaluating new populations on their farms.

PARTICIPATORY VARIETY SELECTION (PVS):
A variety selection approach where farmers work together with other agricultural stakeholders to evaluate which varieties perform best on their farms.

Helene Saby harvesting radishes at Patchwork Farms in Quebec. *Photo credit: Parafilms.*

INTRODUCTION:

Seed Diversity for Climate-Resilient Agriculture in Canada

The Bauta Family Initiative on Canadian Seed Security (the Bauta Initiative), a program of SeedChange, is dedicated to advancing resilient seed systems in Canada. In collaboration with farmers, seed growers, researchers, and farming organizations across the country, we work to increase the quality, quantity, and diversity of Canadian-grown seeds that are adapted to organic, ecological, regenerative, and climate-resilient farming practices.[1]

As climate change challenges mount and agricultural biodiversity diminishes, farmers in Canada are experiencing complex ecological and economic pressures. Canadian agriculture primarily relies on synthetic fertilizer, chemical inputs, and heavy amounts of fossil fuel use in order to be productive, but these practices are contributing to increased greenhouse gas emissions that are worsening the climate crisis.[2]

Furthermore, we have lost 75% of agricultural biodiversity over the last 100 years globally. In Canada, only 10% of the remaining crop varieties are commercially available and virtually all of the vegetable seed used in commercial farming is imported.[3]

This extreme loss in diversity significantly limits Canadian farmers' options to use appropriate varieties in the face of climate change.[4]

Climate-resilient farming systems are becoming increasingly recognized for their ability to reduce on-farm emissions, increase soil health, and enhance on-farm biodiversity.[5] However, these types of agricultural practices in Canada are not widely adopted and farmers face a multitude of barriers when transitioning into climate-resilient approaches.

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[1] The Bauta Initiative primarily works with certified organic farmers, as well as farmers who use "ecological", "regenerative", or "sustainable" practices, without seeking organic certification. All farmers we work with are adopting agricultural practices that reduce the use of fossil-fuel based inputs, exclude the use of agrochemicals, preserve and enhance biodiversity, build soil health, and increase regional food sovereignty. These practices can also fall under a definition of "climate-resilient farming," and this term will be used (in addition to organic, ecological, and regenerative) in this report to refer to the farming systems we work with.

[2] Government of Canada, 2023; Malaj, Freistadt, & Morrissey, 2020; Beingessner & Fletcher, 2019; Alahmad et al., 2023; Laforge, Corkal, & Cosbey, 2021

[3] Levert, 2014

[4] Fu, 2006; Gilbert, 2014

[5] Tuck et al., 2014; Gomiero, Pimentel, & Paoletti, 2011; Lori et al., 2017; Smith et al., 2019; Chiriacò, Castaldi, & Valentini, 2022

One of the most significant and overlooked barriers to their adoption is *seed*. In order for farmers to successfully practice climate-resilient agriculture, they need a diversity of seeds adapted to those conditions. Seeds developed for these types of farming systems need to be able to thrive without the use of synthetic fertilizers, have good pathogen resistance to limit the use of agrochemicals, strong vigour and good leaf canopy to outcompete weeds, and demonstrate strong nutrient use efficiency to perform well in a diversity of fertility regimes and climates.[6]

The majority of farmers in Canada are either reliant on seed developed for high-input farming systems, and/or seed from international seed companies that do not breed varieties adapted for Canadian climates or climate-resilient farming systems.[7] A growing body of evidence is demonstrating that *regionally-produced varieties developed under organic and ecological farming systems* can help farmers develop soil fertility and health, build natural resilience to pests and diseases, adapt to climate variability, and in some cases, provide greater nutritional value and flavour.[8]

However, limited resources are available — both from the private and public sector — for plant breeding programs to develop varieties suitable for climate-resilient agriculture.[9] This lack of investment severely inhibits the growth of this sector, and limits the diversity of varieties available that can thrive in those conditions. Modern seed varieties are also increasingly being released with restrictive intellectual property rights (IPRs) (e.g. plant breeders' rights, plant variety protections, utility patents, variety use agreements) that prevent or limit farmers' ability to save seed.[10] Seed saving is vital not only so that farmers have secure access to their most important input, but also because the practice enables on-farm climate resilience through variety adaptation to specific environments and farming practices.

Despite these limitations, a small but unwavering group of organic and ecological farmers, seed producers, researchers, and farming organizations are contributing significant labour and taking on considerable economic risk to fill this gap. Through on-farm plant breeding, regional seed adaptation and production, and participatory variety trials, this community is strengthening regional seed systems in Canada, and in turn, the climate resilience of Canadian agriculture.

[6] Entz et al., 2018; Murphy et al., 2005; Lammerts van Bueren et al., 2011
[7] Levert, 2014; Bronson, 2015; Howard, 2015; Thoreau, 2021; Lammerts van Bueren et al, 2011
[8] Murphy et al., 2005; Murphy et al., 2007; Shelton & Tracy, 2016; Entz et al., 2018
[9] Hanson, 2007; COTA, 2020
[10] Howard, 2015; Endres, Guarino, and Nathani, 2023; Jenney, 2015

Over the past decade, the Bauta Initiative has offered support to this community through opportunities to participate in on-farm research and knowledge exchange programs that further develop their seed production and plant breeding skills. A particular focus of our research initiatives has been the implementation of participatory plant breeding (PPB) and participatory variety selection (PVS) programs. These methodologies prioritize farmer leadership in evaluating, selecting, and developing varieties, and assert that these activities should happen on farms to replicate the conditions in which the seeds will ultimately be grown.[11] PPB and PVS – established research methodologies internationally – are underdeveloped in North America, but are emerging as empowering approaches for farmers to assert more control over their seed sovereignty.[12]

The Bauta Initiative now works with over 200 organic and ecological farmers across Canada who are producing regional seed of field crops and vegetables that perform well in Canada's diverse growing regions.

This report outlines the findings of the "Growth Opportunities for Canadian-Grown Organic and Climate-Resilient Seed in Canada", hereinafter referred to as the *Climate-Resilient Seed Demonstration Site Project*: one of our most significant interventions to date in support of this sector. Its findings, though preliminary, help validate our belief that the preservation, improvement, and creation of seed diversity are key to helping farmers mitigate the impacts of climate change and enhance biodiversity, while contributing to the long-term sustainability of Canada's seed sector.

Different varieties of wheat grown at the Ironwood Organics in Ontario. *Photo credit: Jackie Clark.*

[11] Almekinder, Thiele, & Danial, 2007; Lammerts van Bueren et al., 2018
[12] Mendum & Glenna, 2009; Ceccarelli & Grando, 2019; Colley et al., 2021; Jensen, Storosko, & Dang, 2024

Watermelon growing at the Fertile Ground Farm in Ontario.
Photo credit: Martina Schaefer.

The varieties showcased in this report and those featured at the demonstration sites are only a small sample of the remarkable seed saving and plant breeding efforts of organic and ecological farmers in Canada.

For gardeners, farmers, and researchers interested in seeing the full diversity of seed being grown in Canada, please visit weseedchange.org/local-seeds.

Leah Collett, demonstration site and farm manager at the PEI Legacy Garden in Prince Edward Island. *Photo credit: Alexander Eastman.*

The Climate-Resilient Seed Demonstration Site Project

The Climate-Resilient Seed Demonstration Site Project

With the support of AAFC's Canadian Agricultural Strategic Priorities Program (CASPP), the Bauta Initiative established a series of seed demonstration sites across the country from 2021–2023.

These demonstration sites were set up on working farms and research institutions and operated **with the goals of:**

1. Showcasing and evaluating organic, ecological, regional seed to increase their use and adoption among fellow farmers and seed growers;
2. Sharing knowledge of regional seed production and on-farm plant breeding methods to increase the capacity of farmers and researchers; and
3. Increasing marketing and value chain opportunities for organic, ecological, regional seed.

Onion plants growing at Abbotsford Research and Seed Education Farm in British Columbia. *Photo credit: FarmFolk CityFolk.*

Trial and showcase gardens hosted by research institutions and private seed companies are common in the seed industry; however, this service is simply not yet established in the organic and ecological sector for field crops or vegetables.[13] Accordingly, these seed demonstration sites sought to not only gather agronomic data on these varieties, but to showcase the incredible work of the organic and ecological farming community, and develop awareness among all agricultural stakeholders about the value of regional seed.

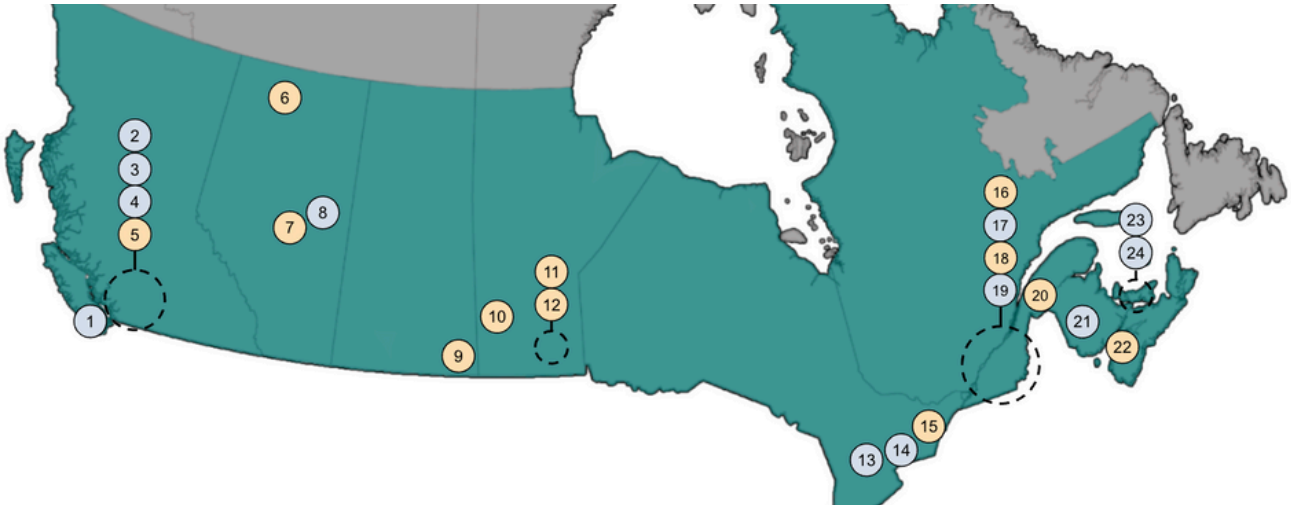
Demonstration sites highlighted two groups of crops: vegetables and field crops. Vegetable sites showcased regional open-pollinated (OP) varieties and/or OP varieties that would be suitable for regional seed production. Field crop sites highlighted farmer-bred varieties, heritage/heirloom grains, and varieties of wheat and oats developed through PPB programs. Demonstration sites were selected and managed collaboratively by the Bauta Initiative, our regional partners (FarmFolk City Folk, Organic Alberta, Ecological Farmers Association of Ontario), and our research partners (University of Manitoba and University of British Columbia). Crop varieties included in all demonstration sites were collaboratively chosen between site managers, regional farmers and seed companies, independent plant breeders, researchers, and regional agricultural organizations.

A map and summary of the demonstration sites can be seen in Figure 1 and Table 1.

FIGURE 1

Geographical distribution of vegetable and field crop demonstration sites across Canada.

A list and summary of demonstration sites can be found in Table 1. Blue circles indicate vegetable sites and yellow circles indicate field crop sites.



Source: FreeVectorFlags.com

[13] Rey et al., 2021; Dawson et al., 2017

TABLE 1

Geographical distribution of vegetable and field crop demonstration sites across Canada.

Blue rows indicate vegetable sites and **yellow rows** indicate field crop sites. Sites with asterisks (*) were managed independently by the University of Manitoba for a separate research project; however, data collected on PPB wheat populations from these sites was shared to be used by the Bauta Initiative for this project.

Site #	Demonstration Site	Region	Years Active
1	Sandown Centre for Regenerative Agriculture	North Saanich, BC	2023
2	Abbotsford Research and Education Seed Farm	Abbotsford, BC	2021–2023
3	Fraser Common Farm Co-op	Aldergrove, BC	2023
4	University of British Columbia Farm	Vancouver, BC	2021–2023
5	Kwantlen Polytechnic University	Surrey, BC	2023
6	Mackenzie Applied Research Association	Fort, Vermilion, AB	2022–2023
7	University of Alberta	Edmonton, AB	2021–2023
8	Peno Creek Farm	Waskatenau, AB	2023
9	Moose Creek Organic Farm*	Oxbow, SK	2021–2022
10	Parkland Crop Diversification Foundation*	Roblin, MB	2021–2022
11	Organic farm*	Libau, MB	2021–2022
12	University of Manitoba*	Winnipeg, MB	2021–2022
13	Fertile Ground Farm	St. Agatha, ON	2022–2023
14	Campus Farm at University of Toronto Scarborough	Scarborough, ON	2022
15	Ironwood Organics	Athens, ON	2023
16	Bishop's University	Sherbrooke, QC	2021
17	La Radicule	Manseau, QC	2022–2023
18	Ferme Céréalière Paquet	Ste-Florence, QC	2022
19	Patchwork Farms	Senneville, QC	2021
20	Vital Potvin and Club de gestion des sols du Témiscouata	Témiscouata-sur-le-Lac, QC	2023
21	Hayes Farm	Fredericton, NB	2022–2023
22	Nikian Gardens	Granville Beach, NS	2023
23	Charlottetown Research and Development Centre	Charlottetown, PEI	2021
24	Legacy Garden	Charlottetown, PEI	2022–2023

For a full list of crops grown at demonstration sites, please see **Appendix A**.

For gardeners, farmers, and researchers interested in seeing the full diversity of seed being grown in Canada, please visit weseedchange.org/local-seeds.

For more information about any of the crops and varieties featured at these demonstration sites, please contact the Regional Coordinators of the Bauta Initiative:

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shughes@weseedchange.org

QUEBEC:
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ONTARIO:
Rebecca Ivanoff, Ecological Farmers Association of Ontario
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PRAIRIES:
Sarah Preston, Organic Alberta
sarah.preston@organicalberta.org

BRITISH COLUMBIA:
David Catzel, Farm Folk City Folk
bcseeds@farmfolkcityfolk.ca

Siri van Gruen, demonstration site manager at Abbotsford Research and Seed Education Farm in British Columbia, prepping beds for planting. *Photo credit: FarmFolk CityFolk.*

Evaluation Methods

The data evaluation methods varied across locations depending on the kinds of crops evaluated and the capacity of the sites. Given the decentralized nature of these sites, managers contextualized crop evaluation to regional climate-resilient farming conditions, as well as the needs and interests of those across their community of growers. Evaluation varied ranging from qualitative observation, quantitative analysis, anecdotal, or a combination of these evaluations.

The types of plots present at these demonstration sites were:

SCREENING/OBSERVATION TRIALS:

Unreplicated trials comparing multiple crop varieties and/or breeding populations to produce qualitative and anecdotal observation. They were used for crops that require further investigation into their basic parameters for cultivation, and/or potential for future selection and breeding work.

VARIETY TRIALS:

Replicated trials comparing overall performance of multiple varieties and/or breeding populations against commercial check varieties to produce shareable data for farmers, seed growers, and researchers. These trials gathered qualitative observation, as well as quantitative data for statistical analysis.

PLANT BREEDING PLOTS:

Plots set up to continue selection on breeding populations of interest for farmers.

SHOWCASE GARDENS:

Plots designed to profile varieties of interest either bred by Canadian farmers, regionally-produced by Canadian farmers, or good candidates for regional seed production. These plots were also used for crops in early stages of breeding to highlight regional on-farm plant breeding projects.

VEGETABLE SEED PRODUCTION PLOTS:

Plots set up to produce vegetable seed and/or evaluate the capacity of crop varieties to produce seed.

SEED INCREASE PLOTS:

Plots set up to bulk up seed for a field crop for a desired acreage that cannot otherwise be done on a farm.

Chris Wooding, owner of Ironwood Organics, showcasing his wheat to visitors at the demonstration site hosted at his farm. *Photo credit: Rebecca Ivanoff.*

Demonstration Site Engagement

Demonstration sites were also hubs for training, education, and engagement among various stakeholders across the agricultural sector, including:

FIELD DAYS:
On-farm educational events for farmers, researchers, and the general public to tour farms, interact with the varieties, and connect with the farmers, breeders, and researchers on a wide range of agricultural issues. These tours also allowed demonstration site hosts to share the day-to-day operations of their site, experiences working with regional seed, and agricultural techniques and equipment used at their sites.

WORKSHOPS:
Virtual or in-person educational events where individuals learned about specific seed production and/or plant breeding topics from farmers and other subject matter experts who were either managing or participating in the demonstration sites.

VARIETY TASTINGS:
Hosted during field days, workshops, and farming conferences to provide individuals with the opportunity to taste varieties grown at demonstration sites and provide feedback on their flavour, appearance, and texture. These tastings also allowed individuals to acquire seed and learn more about the breeding or production history behind demonstration site varieties.

Over the course of this project, our team hosted **45 educational opportunities**, engaging over **1,100 participants** across the country.

Enhanced through social media engagement across a variety of different platforms, these demonstration sites and their related activities provided unique opportunities for farmers and other agricultural stakeholders to learn about organic and ecological seed production and on-farm plant breeding, and to stimulate interest in supporting regional seed systems.

Tasting event at the Coopérative pour l'agriculture de proximité écologique (CAPÉ) conference in Quebec. *Photo credit: Hugo Martorell.*

Fennel growing at Sandown Centre for Regenerative Agriculture in British Columbia. *Photo credit: FarmFolk CityFolk.*

Vegetable Demonstration Sites: Highlights and Results

Context

Canadian organic and ecological vegetable farmers depend heavily on imported seed.

Canada imports approximately $269 million in vegetable seed, of which a significant portion is used on organic and ecological farms.[14] These vegetable varieties are typically bred in the US or Europe, scaled up by seed multipliers in the US, Netherlands, Peru, France, Italy, China, and other countries, and then sold to North American seed companies wholesale. This model of importing, re-packaging, and re-selling seed has become mainstream because it provides high volumes of quality seed at competitive pricing to farmers who need consistency and reliability in their seed supply.[15]

However, this system leaves many vegetable farmers completely dependent on a network of international suppliers for their most critical input. Global supply chain disruptions — as we saw most recently with the Covid-19 pandemic — can seriously jeopardize farmers' seed supply.[16] Organic and ecological vegetable farmers are particularly vulnerable in this model because plant breeding activities and seed supply chains are predominantly designed by and for large-scale, non-organic vegetable producers. Plant breeding requirements unique to Canadian climates, such as shorter days to maturity or unique pest/disease pressures, are not always prioritized by plant breeders serving this seed market. While vegetable breeding and seed production for the organic sector are improving internationally, more attention needs to be given to domestically-produced seed that thrives under climate-resilient farming conditions. There is an enormous economic opportunity for vegetable seed growers in Canada to fulfill a significant proportion of the domestic demand for vegetable seed.

The majority of vegetable farmers are also reliant on hybrid vegetable varieties because of their yields and overall agronomic performance; however, some growers also desire OP varieties due to their ability to produce true-to-type seed and genetic pliability to potentially adapt to a region. Since hybrid varieties do not produce seed that is true-to-type, farmers generally do not save seed from these varieties. The parental lines for these varieties are often protected as trade secrets or through other IPR

[14] Levert, 2014; NFU, 2024a
[15] OECD, 2019; Deuss, Gaspar, & Bruin, 2021; NFU, 2024b (unpublished raw data)
[16] Isbell et al., 2023; Schreiber et al., 2022; Deuss, Gaspar, & Bruin, 2021

mechanisms which further limit the ability to reproduce seed.[17] OP varieties on the other hand, receive comparatively less private and public investment jeopardizing the availability and quality of OP varieties on the market.[18] By increasing investment in organic and ecological OP varieties, Canada can enhance both the quantity, quality, diversity, and resilience of its regional vegetable seed supply.

An important part of the solution to farmer reliance on hybrid and imported vegetable seed, is supporting the adoption, distribution, and commercialization of regional OP varieties. This work necessitates collecting and sharing relevant data with potentially interested farmers and seed producers, as well as building awareness about the work of regional vegetable seed growers in Canada.

The vegetable varieties in the following section have been highlighted due to their agronomic performance, their suitability for regional seed production, their demand from regional farmers/seed producers, or their unique variety history. These varieties exemplify the incredible work farmers and seed growers are engaged in to develop seed that meet the needs of organic and ecological growers, local markets, and regional climates.

[17] Yu & Chung, 2021; Endres & Goldsmith, 2007
[18] Navazio et al., 2012; Phillips, 2008; Hanson, 2007

Flowering potatoes at Sandown Centre for Regenerative Agriculture in British Columbia. *Photo credit: FarmFolk CityFolk.*

Regional Adaptation: Farmers preserving and adapting OP varieties to their climates

Growing vegetable seed at a commercial scale in Canada is challenging. Our short growing season and cold winters present climatic challenges that hinder year-round seed production, and the lack of investment in domestic vegetable seed production capacity impacts our ability to compete with international suppliers.[19] However, domestic seed producers have shown remarkable commitment and creativity in growing good quality seed for most vegetable crops in diverse Canadian environments, which is critical to fostering climate resilience and seed sovereignty.

One strategy is for farmers to adapt OP varieties bred or produced elsewhere to their own growing regions because they exhibit desirable characteristics. As many OPs can have the genetic flexibility and diversity to respond to selection pressures, farmers can make selections to improve traits of interest over time with significant gains.[20] Accordingly, seed growers will often commercialize these varieties through Canadian seed companies after extensive selection and adaptation.

Farmers also adapt heritage and heirloom varieties: varieties that are generally understood to be historically significant, OP varieties that were either bred in Canada in the past, or varieties preserved and adapted by generations by growers for more than 50 years. Many heritage/heirloom varieties have become endangered or extinct due to displacement and lack of investment in favour of modern varieties, and movement towards varieties designed for conventional agriculture. Today, organic and ecological farmers and seed growers are growing out, selecting, and saving seed from these types of varieties in order to preserve their genetics and increase their quality and availability.

The varieties showcased in this section are a sampling of notable imported and heritage/heirloom OP vegetable varieties that have been adapted to Canadian climates and contexts by farmers and seed growers across the country.

[19] Qualman & Tait, 2004; Thoreau, 2021; Hanson, 2007
[20] Serpolay-Besson et al., 2014; Zystro et al., 2021; Entz et al., 2018

One of the many "fan photos" that gardeners send to Greg Wingate of their thriving Latah tomatoes. *Photo shared by Mapple Farm.*

Latah Tomato

Regionally-adapted, regionally-produced

Greg Wingate of Mapple Farm in New Brunswick has been doing continual selections on Latah tomatoes (*Solanum lypersicum*), an award-winning OP tomato variety, developed at the University of Idaho, for the last 20 years.

Greg became interested in Latah as it was the earliest tomato he could find on the market at the time. Earliness in tomatoes is important for Maritime growers due to a short growing season that reduces the opportunity they have for tomatoes to mature and harvest. Early maturity also lends itself to growing tomatoes outdoors, as outdoor tomato field production has been displaced by greenhouse production, which emits more greenhouse gas emissions.[21]

Mapple Farm's Latah tomatoes can be transplanted in May in the field and be ready to harvest by July, steadily yielding tomatoes throughout the remainder of the season. Remarkably, Greg has also experienced some seasons when seeds can be directly sown into the ground and yield well before the end of the season. This level of earliness offers growers in cold regions the same productivity window for tomatoes as their more temperate counterparts. By the end of the season, the plants produce abundant amounts of delicious, red, globe-shaped fruit that are perfect for salads.

Mapple Farm was the first company to introduce Latah in Canada which is now being offered by 10 seed companies in regions across the country. Latah highlights the role that local seed stewards play in shaping gardens and farms across the country by selecting, adapting, and popularizing great varieties.

We interviewed Greg for our SeedHeads/Les Semeurs podcast! Check out this episode and learn how Greg has been adapting varieties to Atlantic Canadian climates for decades.

TRAITS OF INTEREST

earliness, early vigor, high-yielding, great flavour

DEMONSTRATION SITES

Legacy Garden - Charlottetown, PEI

Hayes Farm - Fredericton, NB

SEED PROVIDER

Mapple Farm - Weldon, NB

[21] Cook & Calvin (2005); Maureira, Rajagopalan, & Stöckle, 2022; Ntinas et al., 2017

Strela Green Lettuce

Regionally-adapted, regionally-produced, heirloom

Strela Green lettuce (*Lactuca sativa*) is an heirloom variety of lettuce that dates back to the 1500s. This variety was almost lost until it was reintroduced by Dr. Alan Kapuler of Peace Seeds in Oregon. No Coast Seeds in Saskatchewan is one of two known Canadian companies supporting the variety by adapting it for both regional Prairie growers and the overall Canadian organic and ecological seed market.

Strela Green was grown at Peno Creek Farm demonstration site in Alberta, where its sweetness, bolt-resistance, and unique, long pointy leaves made it an appealing variety to grow, especially during the dry summer season of 2023. According to Samantha Flasha, who managed the demonstration site at Peno Creek, "Growing the Strela lettuce was a joy. It has a super unique shape, with the long pointy leaves. The shape of the leaves reminded me of endive so I expected the taste to be bitter but it remained sweet and tender throughout the summer. It was also very resistant to bolt, despite the super hot weather we had."

Highlighting this variety at the demonstration site gives market gardeners, seed producers, or backyard gardeners the opportunity to learn about this relatively unknown, but unique heritage variety and choose to integrate it in their production. This not only preserves a historically significant variety of lettuce, but also protects the genetic quality and diversity that Strela Green offers to the organic lettuce catalog.

Strela lettuce growing in the field.
Photo credit: No Coast Seeds.

TRAITS OF INTEREST

heat-tolerance, earliness, flavour

DEMONSTRATION SITE

Peno Creek Farm - Waskatenau, AB

SEED PROVIDER

No Coast Seeds - Calder, SK

Joan rutabaga growing at La Radicule in Quebec. *Photo credit: Sophie Bourdon.*

Joan Rutabaga

Regionally-produced, candidate for regional adaptation

TRAITS OF INTEREST

uniformity, appearance, flavour, disease resistance

DEMONSTRATION SITE

La Radicule - Manseau, QC

SEED PROVIDER

Caroline Poirier of Ferme Croque-Saison - Lingwick, QC

Rutabaga (*Brassica napus*) is an excellent storage crop, beloved by gardeners and farmers for its hardiness and flavour. Despite these qualities, rutabaga is a crop that has received very little investment in terms of variety improvement and plant breeding in recent decades. As a point of comparison, based on data from Seeds of Diversity's Ecological Seed Finder, there are 16 varieties of rutabaga available from Canadian seed companies, compared to 1,690 tomatoes or 269 for cucumbers.[22]

Caroline Poirier of Ferme Croque-Saison in Quebec grows Joan rutabaga as part of her market garden. She observed that her strain of Joan lacked uniformity, and could also have improved appearance, taste, and disease resistance. She decided to take on a selection and seed production project in collaboration with La Radicule, a farm specialized in growing organic seed on contracts for regional seed companies, to see if they could improve the variety together.

Caroline invited Marie-Claude Comeau, owner of La Radicule, to her farm to do an initial selection of her most uniform Joan rutabaga roots in Fall 2020. From the population of 4,000 plants, the pair selected the best 50 individuals for overwintering. Marie-Claude then grew this seed from these roots which Caroline used for her market production in 2022 and 2023. Despite only undergoing one round of selection, both Caroline and Marie-Claude observed a notable improvement in uniformity among the population.

Caroline of Ferme Croque-Saison (left), Marie-Claude of La Radicule (middle), and Marilie Croteau (right) harvesting Joan rutabaga in 2021. *Photo credit: Ferme Croque Saison.*

[22] Seeds of Diversity, 2024

“Nous utilisons les semences que nous en a tiré depuis deux ans et sommes très satisfaits. Elles germent bien et nous donnent de délicieux rutabagas de belle taille et uniformes. Nous sommes enjoués et quelque peu étonnés de constater qu'une amélioration a pu être faite en seulement un cycle de reproduction.”

Translation: “We have been using the seeds she got from it for two years and are very satisfied. They germinate well and give us delicious rutabagas of nice size and uniformity. We are delighted and somewhat surprised to see that an improvement could be made in just one breeding cycle.” - Caroline Poirier

In 2023, Marie-Claude did a refined selection of 20 overwintered roots, grew them out, and harvested 500g of rutabaga seed. Caroline and Marie-Claude are excited to grow out this new seed and continue doing selections.

This improved Joan variety highlights how OP crops offer versatile and reliable genetics that farmers can readily adapt to meet their agronomic needs. Seeds that are saved from these improved varieties can be used for future cultivation, breeding work, or sharing amongst other farmers.

(Top) Marie-Claude, of La Radicule, giving a tour of the demonstration site hosted at her farm. *Photo credit: Sophie Bourdon.*

(Bottom) Joan rutabaga growing at La Radicule in Quebec in 2022. *Photo credit: Sophie Bourdon.*

Pile of Paydon acorn squash in the field.
Photo credit: Yonder Hill Farm.

Paydon Acorn Squash

Regionally-adapted, regionally-produced, heirloom

Paydon acorn squash (*Cucurbita pepo*) is an heirloom winter squash that originated in France, then made its way to Louisiana, USA where it was stewarded by the Paydon family since the 1800s. Paydon is beloved for its vigorous growth, delicious flavour, and long storability; however, it requires a long growing season to produce bountiful harvests.

Chris Sanford, of Yonder Hill Farm in Nova Scotia, has been carefully selecting for early maturity in Paydon across 10 growing seasons, with the goal of adapting it to the shorter Maritime growing season. While the original Southern US heirloom has an estimated 105 days to maturity, this adapted Paydon matures in approximately 80 days.

Currently, Yonder Hill Farm is the only seed company in Canada offering Paydon seeds. Chris calls this her favourite variety of acorn squash because of its incredibly sweet and nutty flavour. Leah Collett, Farm Manager at the Legacy Garden demonstration site, observed that Paydon was remarkably productive with a high disease resistance, and that the fruit was delicious and buttery. At a tasting event at the Fertile Ground Farm demonstration site, attendees commented that although Paydon grew like a squash, a crop suitable for cultivation in Ontario, its flavor resembled that of a sweet potato, a crop typically not grown in Ontario.

Seed stewards' efforts to adapt and circulate heirloom varieties makes them more accessible and productive in regional, climate-resilient farming systems, diversifies and enriches vegetable markets and consumer diets, and ensures the availability of good plant genetics for potential future plant breeding.

TRAITS OF INTEREST

earliness, flavour, productivity

DEMONSTRATION SITES

Legacy Garden - Charlottetown, PEI

Fertile Ground Farm - St. Agatha, ON

SEED PROVIDER

Yonder Hill Farm - Laconia, NS

Green Goliath Broccoli

Candidate for regional adaptation, regionally-produced, heirloom

Broccoli (*Brassica oleracea*) is a cool season crop, grown best during shoulder seasons in BC to avoid mid-summer heat, which can result in reduced yields, premature bolting, and seed with diminished viability, quantity, or quality. Green Goliath is a beloved heirloom variety because its large main head and numerous side shoots make it harvestable as both a head and bunching broccoli. While the variety is relatively easy to grow for market, growing it for seed in hot climates can be challenging.

In 2019, Sunshine Farm in Kelowna, BC, experienced intensifying summer temperatures which compromised their seed production for Green Goliath. This prevented their ability to produce seed for on-farm use and commercial distribution. To help restore seed availability, Siri van Gruen, demonstration site manager at Abbotsford Research and Education Seed Farm, grew Green Goliath seed for Sunshine Farm and for sale through the BC Eco Seed Co-op.

This story of Green Goliath highlights how demonstration sites - but more importantly, the broader seed and farming community - can offer both agronomic support and resilience for regional seed production and improvement. As ever-changing climate conditions disrupt the ability for farmers to save their own seed, demonstration sites can act as secondary “insurance” sites for seed production to ensure seed security, or as locales where growers can participate in future selections to improve the variety’s heat tolerance.

Green Goliath broccoli.
Photo credit: David Catzel.

TRAITS OF INTEREST

heat tolerance, extended harvest period, large heads

DEMONSTRATION SITE

Abbotsford Research and Education Seed Farm - Abbotsford, BC

SEED PROVIDER

Sunshine Farm - Kelowna, BC

Seed for the Diasporas: Adapting culturally significant vegetables to Canadian climates

There is a large demand in Canada, by both growers and consumers, for vegetable varieties that hold importance for diaspora communities. Many culturally significant crops that are non-native to Canada require extensive selection work to improve their agronomic performance in Canadian climates and markets. While many of these culturally significant crops are available through regional seed companies, these varieties are often produced elsewhere and have not been evaluated for their performance in climate-resilient farming conditions. Collecting agronomic performance data on culturally significant crops directly from growers provides seed producers with targeted feedback on how their varieties can be improved or regionally-adapted.

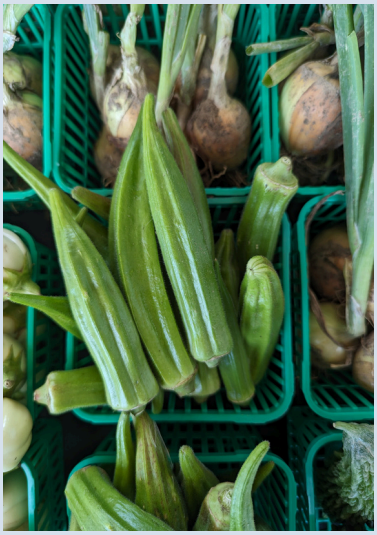
Doing this work in community provides opportunities for knowledge dissemination and exchange, and offers the opportunity to diversify regional seed company catalogues, which helps the sector better serve equity-deserving communities in Canada. Gathering crop varieties of different market classes or originating from different geographical regions offers significant potential for the creation of new varieties through their use in on-farm breeding projects. Some plant breeders are exploring the potential gains in selection that can be generated by crossing varieties across market classes and regions of origin.[23]

Working with this kind of seed diversity also invites opportunities for dialogue and learning on ethical seed stewardship. Seed growers and plant breeders should think through what kinds of commitments are necessary to develop respectful relationships with the communities many of these varieties originate from. Developing seed in collaboration with different communities can ensure that varieties are kept, shared, and maintained in a way that respects traditional knowledge, embraces cultural heritage, and ensures equitable access for all stakeholders over time.

The varieties highlighted in this section showcase crops and varieties that demonstrate the potential of regional adaptation and variety development of growing culturally unique vegetables.

[23] Swarup et al., 2020; Oladosu et al., 2021

Okra going to market.
Photo credit: Rav Singh.



Regionally-Produced Okra

Culturally significant crop, candidate for regional adaptation, regionally-produced

Okra (*Abelmoschus esculentus*) is a popular vegetable in cultures all over the world, and is increasingly in-demand in Canadian urban centres. Although various regional seed companies have produced organic, OP okra varieties, there is not a lot known about what okra varieties grow best in specific regions. In Ontario specifically, finding okra varieties that germinate well, produce high yields, and meet the preferences of local markets is an ongoing challenge for many growers.

As part of the Farmer-Led Research Program, implemented by the Ecological Farmers Association of Ontario, eight growers across southern Ontario and southern Quebec, ran randomized, replicated variety trials of six okra varieties (**Table 2**) grown by regional seed companies on their farms. The Fertile Ground Farm demonstration site also participated in, and acted as, the centralized hub site for this okra trial. Growers rated the okra varieties on germination, early season/post transplant vigour, days to first flower, first harvest and last harvest, yield, marketability, flavour and texture, and overall rating.

TRAITS OF INTEREST

Early maturity,
high yielding,
high germination rate

DEMONSTRATION SITE

Fertile Ground Farm -
St. Agatha, ON

SEED PROVIDERS

Hawthorn Farm
Organic Seed -
Palmerston, ON

Gaia Organic Seeds -
Ottawa, ON

Left: Okra variety trial at Fertile Ground Farm in Ontario. *Photo credit: Janine Stanic, Angie Koch, and Nicola Barsoum.*

Right: Diversity in fruit included in the okra variety trial. *Photo credit: Janine Stanic.*

TABLE 2

ANOVA results and statistical summary of the germination rate, marketability rating, flavour rating, overall rating, and the number of farmers who would grow a variety again across okra varieties.

Different letters indicate a significant difference between varieties, with the letter "a" indicating the greatest value, and so on. The number of farmers who answered whether they would grow a variety again varied due to crop failure.

Variety	Germination rate in 12 days	Marketability rating	Flavour rating	Overall rating	Would you grow it again?
Clemson Spineless	84% a	4.6	3.8	3.6	4/7
Burgundy	45% d	4.3	3.7	3.7	6/6
Jing Orange	57% cd	4.4	3.6	3.1	2/6
Emerald Green	71% abc	4.8	4.0	4.1	6/6
Dwarf Lee	58% bcd	4.4	4.3	4.3	3/6
Lady Finger	83% ab	4.3	3.6	3.2	3/5

Researchers used an analysis of variance (ANOVA) analysis (significance cut-off of 0.05) for the traits listed in **Table 2**, and found variety only had a significant effect on germination rate (p=0.001). Farmers also reported variety-specific issues with disease (like powdery mildew, rust, leaf spot) and pests (like aphids, cucumber beetle, japanese beetle) on their individual farms, likely as a result of the trial occurring across various bioregions. Farmers found that customers familiar with okra seemed to gravitate towards buying varieties that had smaller, green pods, while customers unfamiliar with okra were more attracted to red varieties.

The results of this trial can help farmers and seed growers identify which varieties are in need of further improvement and what the breeding needs are for future okra varieties. The farmers involved in this trial repeated it in 2023 and are awaiting the results. They hope the data can build more robust agronomic and market data on the performance of regionally-produced okra varieties in their regions.

See the full research report for this okra trial at EFAO's Research Library and check out some of the amazing variety adaptation work being done by one of the okra growers, Rav Singh at Shade of Miti here!

Copperhead Amaranth

Culturally significant crop, candidate for regional adaptation

Amaranth (*Amaranthus spp.*) is a culturally significant crop across Asia, Africa, and the Americas, that is harvested for its foliage, grain, and seed. Unfortunately, high-quality organic amaranth seed is not always accessible to purchase in Canada, with even fewer commercial varieties being grown in or adapted to local climates. As amaranth requires hot environments to thrive, growing amaranth in Canadian climates can be challenging.

Iyé Creative, a grassroots food justice collective, identified amaranth as a culturally significant crop in need of further agronomic improvement in BC. Working in collaboration with the BC Sandown demonstration site, the two organizations chose Copperhead amaranth from Adaptive Seeds to grow out as a candidate for regional adaptation, screening it to see if it yielded well for both foliage and grain.

Copperhead offers smaller plants with earlier days to maturity which is ideal for the short growing season in Canada. The variety is also advertised as having high grain yields, and can double as an ornamental plant while the grains are developing and drying on the stalk. Lisa Willott, demonstration site manager, observed that Copperhead yielded much higher amounts of grain than many other varieties of amaranth she has grown. While site visitors were excited about the cultivation of grain amaranth, they also expressed interest in amaranth harvested for foliage.

Copperhead highlights how regional seed adaptation involves not only adapting varieties to local growing conditions, but also local market preferences. Adapting culturally significant crops can be challenging because different diasporic communities prioritize different agronomic and culinary qualities in their varieties. Next year, the site wants to grow more leafy varieties of amaranth to serve a wider need for the community.

Copperhead amaranth going to flower.
Photo credit: FarmFolk CityFolk.

TRAITS OF INTEREST

high yielding for grain, earliness

DEMONSTRATION SITE

Sandown Centre for Regenerative Agriculture - North Saanich, BC

SEED PROVIDER

Adaptive Seeds - Corvallis, OR

Lisa Willott, demonstration site manager at Sandown Centre for Regenerative Agriculture in British Columbia, showcasing Copperhead amaranth. *Photo credit: FarmFolk City Folk.*

Melanzana Rossa Di Rotonda Eggplant

Candidate for regional adaptation, culturally significant crop, heirloom, regionally-produced

Melanzana Rossa Di Rotonda.
Photo credit: Rebecca Ivanoff.

TRAITS OF INTEREST

productivity, fall production, heirloom preservation

DEMONSTRATION SITE

Fertile Ground Farm - St. Agatha, ON

SEED PROVIDER

Gaia Organic Seeds - Ottawa, ON

Eggplants are a staple vegetable crop worldwide, with many varieties having long histories of migration and adaptation to regional climates and cultures. Ethiopian eggplant (Solanum aethiopicum), originating from Eastern Africa, is celebrated for its ease of growing, nutrient density, and diverse shapes and colours.

Melanzana Rossa Di Rotonda was originally an Ethiopian eggplant variety that was brought over to Italy from Ethiopia in the 1930's. The variety was eventually championed as the "Red Eggplant of Rotonda," named after the mountain village in southern Italy, in which it was adapted. In 2009, Jere Gettle brought these seeds from Italy to Missouri, where they were distributed through Baker Creek Heirloom Seeds to Manish Kushwaha of Gaia Organic Seeds, in Ottawa, in 2021. Ever since, Manish has been stewarding and making selections to improve this variety's regional adaptation, productivity, and extension into the fall season.

Melanzana Rossa Di Rotonda is versatile as its fruit can be cooked, preserved, and pickled, while its tender leaves can also be eaten raw or cooked. With the fruit having a vibrant orange colour and a flavor profile being a blend of eggplant, tomato, and sweet pepper, this variety is reflective of the regions where it has been adapted. During a tasting event at the Ontario demonstration site, many attendees loved the unique, slightly bitter flavour and velvety texture of this eggplant.

With deep significance across many different cultures, preserving the genetics of eggplant varieties like Melanzana Rossa Di Rotonda is crucial. This variety is another example of how organic and ecological seed producers invest considerable effort to preserve culturally significant crops for regional adaptation. Their endeavours enrich the diversity of crops available in the seed market and increase their ability to thrive in climate-resilient farming systems.

Creating New Seed Diversity: Developing seed for future generations

For thousands of years, growers have been using OP varieties as the foundation for on-farm seed saving, adaptation, and plant breeding. OP varieties provide the diverse and preliminary genetics for producing new crop varieties. Despite this importance, OP variety improvement and development receives less investment compared to hybrids.[24] This is a barrier to greater adoption of OPs by farmers in their production systems, and a barrier to all growers interested in saving and adapting OP varieties to their farm and using those OPs to develop new varieties.

The varieties highlighted in this section showcase how OP varieties can provide organic and ecological farmers with foundational genetics for breeding new varieties.

These stories also demonstrate the incredible ingenuity of organic and ecological farmers and seed growers, and the enormous potential for farmer-led variety creation. Expanding the diversity and accessibility of high-quality OP varieties is essential for increasing seed sovereignty, fostering farmer-led plant breeding efforts, and enhancing seed diversity in climate-resilient agriculture.

Harvesting hot peppers for seed at La Radicule in Quebec. *Photo credit: Hugo Martorell.*

[24] Navazio et al., 2021

Renegade Red Pepper

Regionally-bred, regionally-adapted, regionally-produced

Growing peppers organically in Ontario can be challenging due to regional pest pressure and cold climates which slow down maturation and fruiting. As a result, many growers rely on hybrid pepper varieties, which are hardier than OPs against these challenges, but which do not produce true-to-type seed. To address this gap, SeedWorks Plant Breeding Club – a collaboration between farmers, breeders, and researchers in Ontario – developed an OP pepper suitable for regional organic and ecological conditions, prioritizing red, blocky, and tasty fruit.

SeedWorks initiated this breeding project in collaboration with plant researchers at Cornell University. They crossed Ace F1 with Aristotle F1, respectively known for their earliness and blockiness as peppers, and popularity among regional growers. These varieties were highly favored among regional growers for their exceptional quality and vibrant red color. SeedWorks grew out the seed from this cross, selected for their favourite plants, and pooled seed from multiple farms over several years to develop what is now the pepper variety, Renegade Red (**Figure 2**).

Renegade Red (middle) beside its original parents, Aristotle (left), and Ace (right). *Photo credit: Rebecca Ivanoff.*

Renegade Red peppers growing at Fertile Ground Farm as part of the Farmer Led Research red pepper trials. *Photo credit: Janine Stanic.*

TRAITS OF INTEREST

blocky fruit shape, red fruit, good flavour, earliness, vigour

DEMONSTRATION SITE

Fertile Ground Farm - St. Agatha, ON

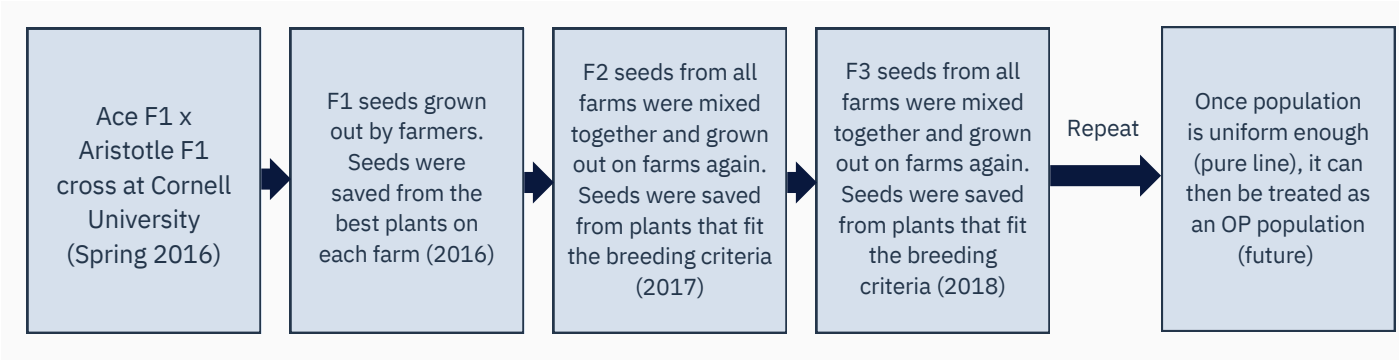
SEED PROVIDER

Hawthorn Farm Organic Seeds - Palmerston, ON

FIGURE 2

Breeding history of Renegade Red over time.

Adapted from Ivanoff (2019).



In 2022, Renegade Red was evaluated in a red pepper variety trial in southern Ontario against popular F1 and OP varieties of red peppers. While Renegade Red was one of the lower performing for germination, early vigour, and yield, it was ranked one of the highest for flavour. Ace F1, one of the original parents of Renegade Red, was the best performing, highlighting that Renegade Red still has more selection work to undergo in order to compete with its parent.

"For the trial, Ace was the largest overall producer but for flavour the Renegade Red won hands down. So moving forward I will grow both varieties but I will only be growing in a poly tunnel for production as the yields are better." - Matthew Brearley, Castlegarth Farm

Renegade Red, currently in its F6 generation, is available for purchase through various seed companies across Canada. It is also registered with the Open-Source Seed Initiative, a program that ensures equitable access to plant genetics for farmers, breeders, and others within the agricultural community. Using the same pedigree of Renegade Red, Dan Brisebois at Tourne-Sol Co-operative Farm, was able to produce his own variety of blocky, red peppers called, Feu Rouge.

Renegade Red highlights the power of collaborative, farmer-led plant breeding to create new varieties for regional farming contexts. Although developing a new OP variety takes considerable time and effort, the breeding process used with Renegade Red is one that can be incorporated into the workflow of most seed companies and diversified vegetable farmers. This kind of work gives farmers control over their seed supply, opportunities for collaboration, strengthens seed sovereignty, and continues innovation in regional organic and ecological farming systems.

To learn more about Renegade Red, check out the EFAO's Research Library, listen to a lovely podcast episode with SeedWorks' member, Annie Richard, or watch a presentation by SeedWorks' member, Rebecca Ivanoff!

Plants being marked for Seedworks' sweet pepper breeding project. *Photo credit: Annie Richard.*

Purple Gorria pepper growing at Jardins de l'Ile-Dupas in Quebec. *Photo credit: Jardins de l'Ile-Dupas.*

Purple Gorria Pepper

Regionally-bred, regionally-produced, candidate for regional adaptation

This purple Gorria pepper variety (*Capsicum annuum*) is an OP plant breeding project among farmer-breeders and seed companies across Quebec to produce a purple Gorria (an Espelette-like) pepper.

Originally domesticated in Central America, chilli peppers were widely adopted by the Spanish and Basque cuisine during the 16th century. The Basque often came to fish on the coasts of Gaspésie, Quebec, bringing spices with them, introducing these Espelette peppers into the Quebec culinary landscape and establishing it as an heirloom variety. Today, these peppers must adhere to specific standards in their cultivation to be labelled as "Espelette", a protected designation of origin (appellation d'origine protégée). Often, when grown outside of the Basque region, this pepper is given the name of “Gorria”.

After testing dozens of pepper varieties with his customers in Quebec, Jean-Francois Daoust found that they liked the mild, smoky flavour of Gorria peppers. Noticing an accidental cross in his Cayenne pepper crop which gave him purple fruits gave Jean-Francois the idea to start his own on-farm breeding project. Inspired in part by SeedWorks, the goal was to develop a new, regional pepper variety with the shape of a Gorria pepper and the colour of the purple Cayenne that is widely adapted to Quebec. The La Radicule demonstration site was one of ten organic farms to undertake pepper selections and contribute an equal quantity of seeds to the genetic pool.

Of the 180 plants grown out from the original selection pool at La Radicule, 18 plants were selected for their purple colour. Of these 18 plants, seven had the shape of a Gorria. After tasting the fruits of these seven plants, four were not spicy, while three were pleasantly spicy — seeds of these three plants were saved for future breeding work. Now in its F3 generation, growers seek to select these plants further for earliness and regional adaptation.

TRAITS OF INTEREST

colour, shape, flavour, earliness

DEMONSTRATION SITE

La Radicule - Manseau, QC

SEED PROVIDER

Jean-Francois Daoust of Jardins de l’Ile-Dupas - La Visitation-de-l'Ile-Dupas, QC

“Le piment qu'on cultive est vraiment apprécié de notre clientèle, plus que tous les autres : pour son goût parce que c'est un piment sucré et très peu piquant, et sa grosseur, parce que c'est un piment charnu. À partir de là, on a eu l'idée de développer un piment qu'on pourrait s'approprier, nous les Québécois.”

Translation: “The pepper we grow is really appreciated by our customers more than any other: for its taste because it is a sweet pepper with very little heat, and its size because it is a fleshy pepper. From there we had the idea of developing a pepper that we Quebecers could make our own.” - Jean-Francois Daoust

The development of this culturally significant pepper was made possible by the OP varieties that laid the genetic foundation for this new plant breeding project. Farmers need access to high-quality OP seeds in order to ensure the sustainability of similar farmer-led breeding projects. On-farm plant breeding projects, such as this one, contribute to diversifying the organic seed market, thereby strengthening and enriching climate-resilient seed systems.

Jean-Francois Daoust and Francis Gagnon did a virtual overview on the basics of pepper breeding! Check out this video on how they approach breeding peppers for regional, organic conditions.

Lil Red N Black Cherry Tomato

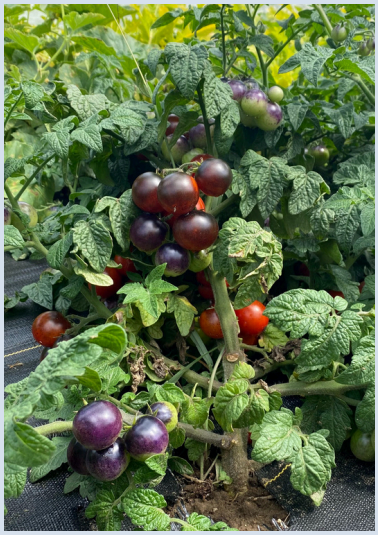
Regionally-bred, regionally-produced

Duane Falk and Vita Gaike at Mimosa Research Farm near Hillsburgh, Ontario wanted to create a beautifully coloured cherry tomato that was also delicious, productive, and easy to manage. By crossing Dwarf Red Cherry with Indigo Black tomato through multiple generations, Lil Red N Black was born.

Lil Red N Black grows vigorously regardless if they are grown as branching, field, container, or pruned tomatoes. They start bearing fruit early in the season up until the last frost, making them extremely productive. They produce a cherry-sized, near-black fruit that then shows red when fully ripe. They are also resistant to late blight and most other common tomato diseases.

Lil Red N Black impressed visitors at the Fertile Ground Farm demonstration site specifically with its flavour and colour. After seeing this new variety at a field day, Kim Delaney was so impressed with the variety that she chose it for distribution through her company, Hawthorn Farm Organic Seeds, making Lil Red N Black available to the public for cultivation. The commercial adoption of this variety shows how demonstration sites offer seed companies the opportunity to interact with advanced breeding lines and new varieties as well as local on-farm breeders, then invest in the commercialization of these varieties if they perform well.

Lil Red N Black growing in the field at Fertile Ground Farm in Ontario. *Photo credit: Angie Koch, Janine Stanic, and Nikola Barsoum.*



TRAITS OF INTEREST

taste, colour, dwarf size, earliness, productivity

DEMONSTRATION SITE

Fertile Ground Farm - St. Agatha, ON

SEED PROVIDER

Duane Falk and Vita Gaike of Mimosa Research Farm - Hillsburgh, ON

Farmer Nikola Barsoum, showing off Lil Red N Black tomatoes at Fertile Ground Farm field day in Ontario. *Credit: Duane Falk.*

Golden Chioggia and Stripes ‘n Gold Beets

Regionally-bred, regionally-produced

Stripes ‘n Gold beet cross-sections.
Photo credit: David Catzel.

TRAITS OF INTEREST

Golden Chioggia - golden red colour with distinct striped pattern;

Stripes ‘n Gold - large size, vigour, colour and pattern diversity

DEMONSTRATION SITE

Fraser Common Farm Co-op - Aldergrove, BC

SEED PROVIDER

BC Eco-Seed Co-op - Aldergrove, BC

In 2016, the University of British Columbia (UBC) and FarmFolk CityFolk coordinated a series of participatory variety trials on beets. One of the participating farmers, Mel Syvestre of Grounded Acres Organic Farm, selected the best performing gold beets and best performing striped beets across all the varieties in the trial. Interested in seeing what these beets would produce when crossed, Mel planted both varieties as one population for seed production in 2017. David Catzel, at Glorious Organic Co-op (housed at Fraser Common Farm Co-op), also grew both varieties but in alternating rows, making sure to separate seeds coming from gold roots versus those coming from striped roots.

The two growers have since been selecting for different traits out of their populations. Mel has been selecting for striped beets with a more golden hue than typical red-striped beets. Meanwhile, David has been selecting for the largest and healthiest looking roots that are gold or striped, prioritizing diversity in the population.

David continued selections and seed production on his population at Fraser Common Farm Co-op demonstration site from 2021–2023.

Currently, Golden Chioggia (Mel’s population) and Stripes ‘n Gold (David’s population) are being sold as “breeding projects” to gardeners and farmers through BC Eco Seed Co-op. Although these populations are still segregating, they already show noticeable trends in their appearance and performance. The diversity present within these populations enhances their marketability, as Mel and David have observed that consumers in their regions favor beets with unique colors and patterns. Golden Chioggia and Stripes ‘n Gold exemplify how mass selection breeding techniques can easily be adopted by farmers to produce varieties that meet their personal preferences and those of their customers. Furthermore, the farmers who purchase this seed can use it as an education tool for on-farm selections, breeding, and seed production.

Golden Chioggia beet.
Photo credit: BC Eco Seed Co-op.

This story demonstrates the potential of farmer-led breeding projects using OP material, and the importance of ensuring that diverse genetics are available to the public in order to launch the development of new and innovative crop varieties.

We talked with Mel about her Golden Chioggia Beets on our SeedHeads/Les Semeurs podcast! Check out this episode to learn more about Mel's passion and methods for beet breeding, and how this population offers opportunities for seed biodiversity.

CANOVI carrot variety tasting at the Ecological Farmers Association of Ontario Conference. *Photo credit: Mike Smith.*

Canadian Organic Vegetable Improvement Project (CANOVI)

Canadian Organic Vegetable Improvement Project (CANOVI)

In collaboration with the University of British Columbia's Centre for Sustainable Food Systems (CSFS) and funded through AAFC's Organic Science Cluster, the Bauta Initiative runs the Canadian Organic Vegetable Improvement Project (CANOVI) through a collaborative network of farmers and researchers who work together to evaluate the performance of OP vegetable varieties in on-farm conditions.

The main goals of this project are to:

1. Test vegetable varieties for adaptation to ecological practices, nutrition and flavour, and/or domestic seed production potential in Canada.
2. Generate and share varietal data with farmers and seed producers.
3. Collect and analyze agronomic data to assess crop performance in organic systems.
4. Implement on-farm participatory plant breeding to create new lines of priority vegetable crops, and
5. Build farmer capacity for on-farm trialing and breeding.

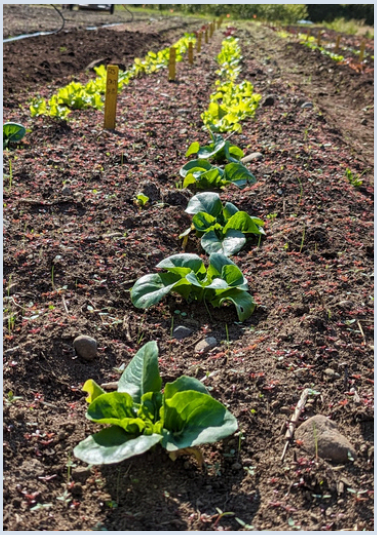
CANOVI orange carrot varieties being pulled out of the field. *Photo credit: Chris Thoreau.*

Since 2018, over 100 farmers have conducted variety trials on over 50 vegetable varieties to evaluate their performance in regional, organic growing systems. Crops that CANOVI has evaluated include peppers, rutabaga, radicchio, and most recently, lettuce and carrots. These trials have produced extensive agronomic data on essential agronomic traits and farmer observations on variety performance in the field. CANOVI has also facilitated multiple workshops and webinars in order to train farmers on practical skills and knowledge related to seed breeding, organic cultivation, and agronomic assessment. These trials have also established robust practices for running decentralized, organic variety trials across the country.

This section provides an overview of results for some of the nationally-coordinated trials for carrots and lettuce completed as part of the *Climate-Resilient Seed Demonstration Site Project*.

Setting up carrots for flavour evaluations as part of CANOVI orange carrot variety trials at the University of British Columbia Farm. *Photo credit: Chris Thoreau.*

CANOVI lettuce transplants.
Photo credit: Chris Thoreau.



TRAITS OF INTEREST

germination, vigor, heat tolerance/bolt resistance, uniformity, yield, marketability, appearance, flavor

DEMONSTRATION SITES

University of British Columbia Farm - Vancouver, BC

Fertile Ground Farm - St. Agatha, ON

Fraser Common Farm Co-op - Aldergrove, BC

Sandown Centre for Regenerative Agriculture - North Saanich, BC

CANOVI Lettuce Trial

Candidates for regional adaptation, regionally-produced

Leafy greens are an essential market crop for Canadian organic and ecological farmers and consistently rank highest as crops in need of breeding improvement.[25] In 2023 we launched CANOVI heat-tolerant lettuce variety trials where growers evaluated twelve OP regional lettuce varieties in their fields and rated them for important agronomic qualities, including bolt resistance (**Table 3**).

As summer temperatures and related pest pressures increase in many regions across Canada, farmers are prioritizing finding the lettuce varieties that will stand up to the heat.

CANOVI lettuce varieties going to seed at the University of British Columbia Farm. *Photo credit: Chris Thoreau.*

[25] Dey et al., 2018

CANOVI researchers at the University of British Columbia Farm planting lettuce seedlings. *Photo credit: Aabir Dey.*

SEED PROVIDERS

Annapolis Seeds - Middleton, NS

Hawthorn Farm Organic Seeds - Palmerston ON

Saanich Organics - Saanichton, BC

Jardins de l'Écoumène - Saint-Damien, QC

Yonder Hill Farm - Laconia, NS

Salt Spring Seeds - Salt Spring Island, BC

Sage Garden Greenhouses - Winnipeg, MB

La Société des Plantes - Kamouraska, QC

Wildrose Heritage Seed Company - Lethbridge, AB

Ferme Coopérative Tourne-Sol - Les Cèdres, QC

TABLE 3

Average rating (1-5) for agronomic traits across lettuce varieties, split up by market class (n=52).

Bolded scores represent the statistically significant highest score(s) among the twelve varieties. Multiple highlighted scores in the same column indicate no statistical difference. Symbols denote the level of significance that variety has on agronomic traits (*** p<0.01, ** p<0.1, * p<0.05, ^ p=0.05, - not significant) based on ANOVA analysis.

Market Class	Variety	Germination ***	Vigor ***	Bolt Resistance **	Uniformity -	Yield *	Marketability *	Appearance ***	Flavor ***	Overall *
Batavian	Cardinale	3.68	**3.95**	4.00	3.86	3.71	3.58	4.15	3.44	3.51
	Cougar	3.20	3.56	3.72	3.43	3.35	3.35	3.83	3.45	3.55
	Gentilina	**4.15**	3.74	3.39	3.65	3.72	3.16	3.74	3.32	3.06
	Magenta	3.24	**3.94**	4.37	3.88	**3.85**	**3.84**	**4.21**	**3.95**	**3.75**
Butterhead	Butter-crunch Bibb	3.92	3.06	4.11	3.41	2.96	2.72	3.19	3.79	2.88
	Butter King	2.06	3.03	4.06	3.42	3.19	3.18	3.56	3.50	3.00
	Grosse Blonde Paresseuse	3.95	**4.00**	3.95	**3.97**	3.71	3.29	3.82	2.97	3.20
	Sangria	3.52	3.35	**4.40**	3.53	3.35	3.23	3.83	3.72	3.44
Oak Leaf	Bronze Beauty Arrow-head	3.56	3.75	3.90	3.95	3.60	3.61	3.87	3.43	3.64
	Biscia Rossa	3.00	3.71	3.61	3.91	3.63	3.62	3.61	3.75	3.46
	Red Oak Leaf Alberta	3.18	2.77	3.18	3.40	2.68	2.86	3.24	2.87	2.62
	Red Oak Leaf Quebec	3.15	3.04	3.96	3.51	2.94	3.14	3.57	2.90	3.06

Despite variety having significant effects on agronomic traits, varieties did not do specifically better or worse based on region. Magenta (from Saanich Organics) and Sangria (from Salt Spring Seeds) were the strongest performing varieties for various agronomic traits including bolt resistance, with participants voting Magenta (82%) and Sangria (78%) as varieties they would grow again.

Results reflect that participants were encouraged to review which lettuce varieties worked best in their specific regional climate and farming systems, with national data also available to act as a point of comparison as needed. CANOVI's on-farm heat tolerance lettuce trials will be continuing in 2024 in order to build multi-year data on how lettuce varieties perform under ever-changing climate conditions.

Participating CANOVI farm, Emmerdale Eden Farm in Prince Edward Island, trialing various lettuce varieties. *Photo credit: Emmerdale Eden Farm.*

CANOVI carrot varieties being showcased at a farm tour day at Sandown Centre for Regenerative Agriculture in British Columbia. *Photo credit: FarmFolk CityFolk.*

CANOVI Orange Carrots

Regionally-adapted, regionally-bred, regionally-produced

Carrots are a staple crop in North American food systems for their storability, nutrition, and flavour. The majority of commercial carrot seed production focuses on hybrid variety improvement, with few OP varieties being bred for performance in regional climatic conditions or organic and ecological farming systems.[26] CANOVI participants expressed that they were looking specifically for Nantes-shaped, orange carrots that are tasty, deep orange in colour, have good storability, and grow well for reliable root and seed production.

To address this need, growers and researchers have been conducting variety trials of various OP Nantes-type carrot varieties with similar F1 varieties. This work has been carried out since 2019 in collaboration with the Organic Seed Alliance and Carrot Improvement for Organic Agriculture (CIOA), extending the trialing network and data sharing across the US, and enabling us to offer a greater diversity of organically-bred carrot lines.

Across trial years, researchers found that variety consistently had significant effects on canopy cover, germination, marketability, uniformity, vigour, and yield (**Table 4**). While hybrid varieties were frequently received the highest for all agronomic traits from growers, OP varieties such as Touchon Deluxe (from BC Eco Seed Co-op), CANOVI Orange (from CANOVI/UBC), CIOA Orange Flavour (from CIOA), and CIOA Orange Strain Cross (from CIOA) closely followed in ratings. In 2023, 72-85% of growers said they would grow these same varieties again in the future.

TRAITS OF INTEREST

germination, vigor, bolt resistance, uniformity, yield, marketability, appearance, flavor

DEMONSTRATION SITES

University of British Columbia Farm - Vancouver, BC

Campus Farm at University of Toronto Scarborough - Scarborough, ON

Fertile Ground Farm - St. Agatha, ON

Fraser Common Farm Co-op - Aldergrove, BC

Sandown Centre for Regenerative Agriculture - North Saanich, BC

[26] Simon, 2000; Hart & Butler, 2004

CANOVI orange carrot variety harvest at Fraser Common Farm Co-op in British Columbia. *Photo credit: FarmFolk CityFolk.*

SEED PROVIDERS

University of British Columbia (UBC) - Vancouver, BC

Johnny's Selected Seeds - Winslow, ME

Organic Seed Alliance - Port Townsend, WA

BC Eco Seed Co-op - Aldergrove, BC

Carrot Improvement for Organic Agriculture (CIOA) - Madison, WI

Fruition Seeds - Naples, NY

TABLE 4

Average rating (1-5) for agronomic traits across orange carrot varieties in 2022 (n=30) and 2023 (n=44) variety trials.

Symbols denote the level of significance that variety has on agronomic traits (*** p<0.01, ** p<0.1, * p<0.05, ^ p=0.05, - not significant, N/A data not collected) for 2022 (upper row) and 2023 (lower row) based on ANOVA analysis. Different letters indicate a significant difference between varieties, with the letter "a" indicating the greatest value, and so on.

Year	Variety	Appearance - ***	Canopy Cover *** ***	Flavor - *	Germination *** ***	Marketability ^ ***	Uniformity * ***	Vigor *** ***	Yield *** ***	Overall N/A ***
2022	Bolero F1	3.9	4.0	4.0	4.2	3.9	3.9	4.3	4.1	N/A
	Naval F1	3.7	3.5	3.8	3.6	3.9	3.8	3.6	3.6	N/A
	Touchon Deluxe OP	3.6	3.4	3.6	3.2	3.7	3.3	3.4	3.4	N/A
	Dulcinea OP	3.6	3.0	3.7	2.8	3.5	3.4	3.2	3.0	N/A
	CANOVI Orange OP	3.3	2.0	3.6	1.2	3.1	3.1	2.9	1.8	N/A
2023	Bolero F1	4.2a	4.3a	4.0a	4.3a	4.3a	4.2a	4.4a	4.4a	4.2a
	CANOVI Orange OP	3.9ab	3.9ab	3.8ab	3.8b	3.7b	3.6b	3.8b	3.8b	3.8b
	CIOA Orange Flavour OP	3.8ab	3.6bcd	3.9ab	3.4bc	3.8b	3.6b	3.7b	3.3cd	3.6bc
	CIOA Orange Strain Cross OP	3.9ab	3.8abc	3.5ab	3.5b	3.9b	3.6b	3.7b	3.5bc	3.7b
	Touchon OP	3.7bc	3.4cde	3.7ab	2.9cd	3.6bc	3.3bc	3.2c	2.9de	3.3cd
	Dulcinea OP	3.4cd	3.2de	3.8bc	2.8d	3.2cd	3.1cd	2.9c	2.7ef	3.0de
	Uberlandia OP	3.1d	3.1e	3.2c	2.5d	2.8d	2.9d	2.8c	2.3f	2.7e

These trials provide robust agronomic data on regionally-produced, OP carrots that help growers in choosing which carrots are best suited to their farms and regional markets. This data also highlights to carrot breeders what qualities of OP carrots are still in need of breeding improvement; specifically, early productivity traits such as germination and uniformity. With more trials like these, regionally-produced OP carrot varieties become better supported in their development and performance, thus building a stronger organic seed system.

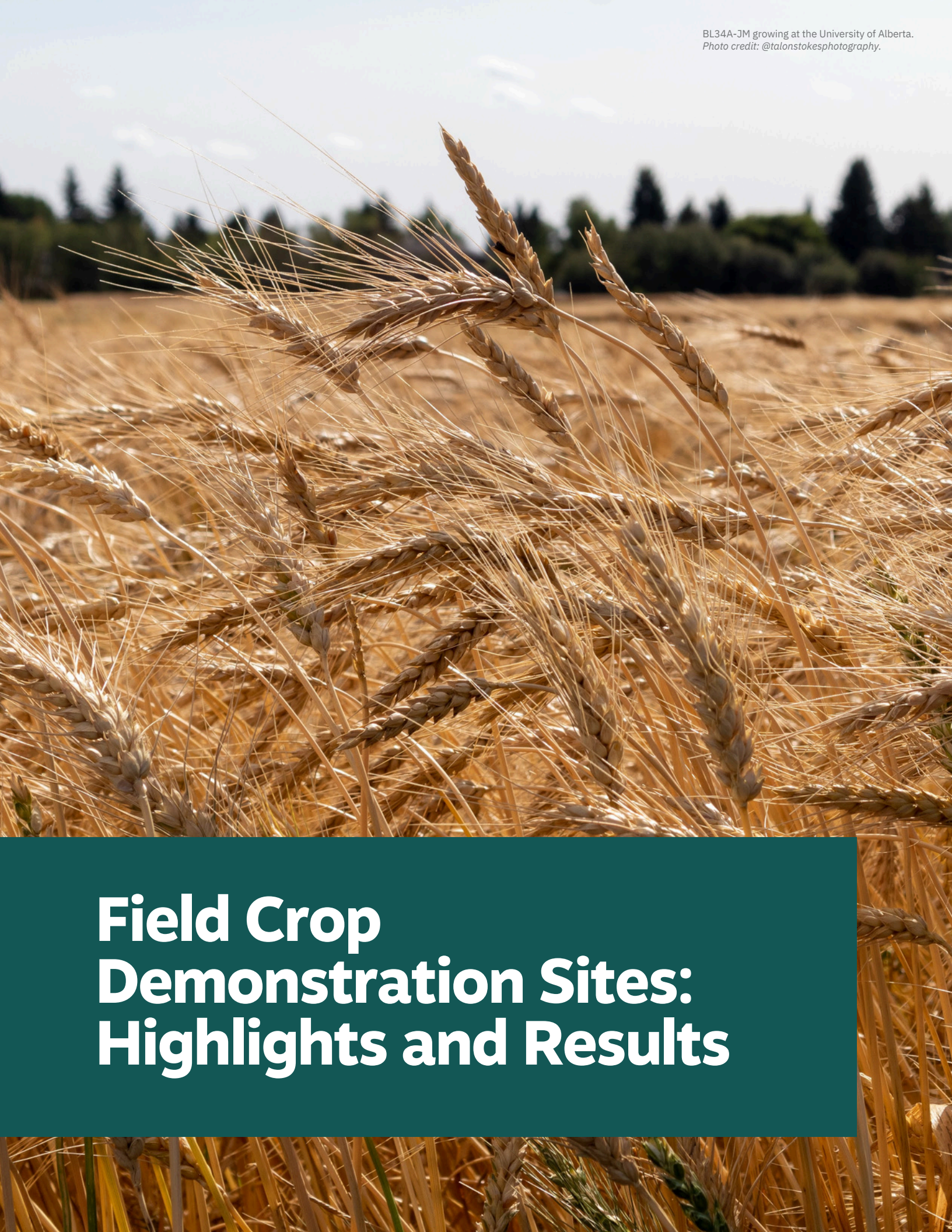
Interested in more results from this trial? Read our 2022 and 2023 full trial reports!

CANOVI demonstrates how a collaborative network involving farmers, seed companies, and plant breeders can meet diverse stakeholder needs.

CANOVI specialty carrot harvest at Fraser Common Farm Co-op in British Columbia. *Photo credit: FarmFolk CityFolk.*

To learn more about our CANOVI program, visit seedsecurity.ca/canovi for more trial results, protocols, and webinars!

Researchers harvesting roots as part of CANOVI orange carrot variety trials at the University of British Columbia Farm. *Photo credit: Chris Thoreau.*



BL34A-JM growing at the University of Alberta.
Photo credit: @talonstokesphotography.

Field Crop Demonstration Sites: Highlights and Results

Context

Organic field crop production in Canada is in the middle of a significant transition.

The rise of regenerative agriculture as a solution to building soil quality has significantly changed the discourse on organic agriculture, especially for field crop growers in the Prairies. "Regenerative organic" has emerged as a way to distinguish farmers who are aspiring to incorporate the no-till practices of regenerative farming, but still excluding the use of synthetic fertilizers, herbicides, pesticides, and other agrochemicals.[27] While there is limited data available on the statistics of organic, ecological, and regenerative organic field crop production in Canada, we estimate that there are approximately 3,200 certified organic field crop producers growing on just under one million acres.[28]

Regardless of the labels used to describe field crop farming in Canada, all field crop farmers are facing complex and intersecting environmental, social, and economic challenges: rising energy and input costs, increased weather extremes, increasing GHG emissions, loss of biodiversity and water availability, degraded soil health, and vulnerability to global shifts in demand for Canadian exports.[29] In addition to these challenges, farmers seeking to reduce the use of fertilizers and agrochemicals face unique agronomic issues (e.g phosphorus and sulfur deficiency), increased pathogen pressures (e.g. wheat midge and anthracnose), and shifting market dynamics (e.g. regression of organic field crop prices, increased competition from competing certifications).

Some of these challenges can be mitigated through agronomic extension and market development programs, but investing in variety adaptation and development would complement these strategies and offer growers increased options in the medium and long term. Researchers in the organic sector all over the world are demonstrating that developing varieties for organic systems can have significant impacts on improving yield, weed competitiveness, nutrient-use efficiency, and pest and pathogen resilience.[30] Innovative field crop growers are also adapting varieties of heirloom/heritage grains for regional climates and creating new direct marketing opportunities that help diversify revenue streams for farmers. Although Canada's public plant breeding programs for cereals and field crops remain relatively robust, funding for these types of programs has been on the decline and there has been limited investment in the development of varieties for regenerative organic farming conditions.[31]

[27] Squires, 2023
[28] Chen, 2022; Wichers, 2022
[29] Martens, Entz, & Wonneck, 2015
[30] Entz et al., 2018; Murphy et al., 2005
[31] Grey et al., 2017; AIC, 2017

The regulatory landscape for field crop seed in Canada also presents challenges. Restrictive intellectual property rights (IPRs) on field crop varieties are increasingly more common in Canadian agriculture. The use of these IPR mechanisms has decreased available seed diversity for organic farming systems where seed saving is common practice. There are also considerable agronomic challenges of producing certified organic field crop seed under Canada's pedigreed seed system and there are regulatory barriers that limit the circulation of seed from unregistered heritage/heirloom grain varieties. All of these barriers combined limit access to a diversity of varieties that organic, ecological, and regenerative organic field crop producers seek to suit their farming systems.

Similar to the organic and ecological vegetable farming sector, field crop farmers are leading the way to develop solutions to these challenges by engaging in on-farm plant breeding and seed adaptation projects. These initiatives aim to develop and adapt varieties of grains and field crops to thrive in a variety of regional farming conditions that do not use synthetic fertilizers or agrochemicals, use specific kinds of cultivation equipment to minimize tillage and control weeds, and are suitable for markets that fall outside of the commodity grain value chains.

The varieties showcased in this section of the report will focus on new varieties of grains developed by farmers and researchers for climate-resilient systems, as well as heritage/heirloom varieties of field crops being adapted to specific climates.

Dr. Michelle Carkner with Ian and Linda Grossart of Howpark Farm at the University of Manitoba, a hub for field crop research. *Photo credit: Marianne Helm.*

Participatory Plant Breeding in Canada

The University of Manitoba, in partnership with the Bauta Initiative, has been running a national participatory plant breeding (PPB) program to develop farmer-bred wheat and oat varieties that thrive in climate-resilient farming conditions. For this PPB program, farmers across the country received multiple populations of wheat and oats and conducted on-farm selection to develop either advanced breeding lines, composite populations, or finished varieties that would perform well on their farms. This approach, which prioritizes the knowledge and needs of farmers and the importance of conducting selections on working farms, can be a low-cost approach to variety development for *all farmers* and plant breeders seeking to develop varieties adapted to climate-resilient farming practices.

Through surveying farmers, we found that their main motivations for participating in PPB are:

- Improved organic production capacities
- Movement towards greater seed sovereignty
- Farmer empowerment in the research and development process
- Support for scientific innovation in Canada
- Increased collaboration and cooperation between farmers and researchers

After participating in PPB, farmers expressed that the primary values they see in PPB are:

- Reinforced sense of empowerment
- Greater autonomy in farming
- Emphasized role of farmers in food sovereignty
- Democratic model of research
- Increased genetic resources and agronomic tools

Over the last 10 years, over 65 farmers have participated in the PPB program to develop over 100 farmer-bred grain populations. Farmers use a mix of selection methods to prioritize a diversity of agronomic characteristics in their wheat and oat populations (**Table 5**).[33] The differences in selection methods, selection timing, and agronomic trait selection both within and between regions and farms demonstrate that farmers have specific traits that they want to see in their crops. Accordingly, in just three rounds of PPB selections some farmers were able to produce distinctively different lines of wheat, even when lines come from the same pedigree.[34]

[32] Jensen, Storosko, & Dang, 2024
[33] Ibid
[34] Entz et al., 2018

For a comprehensive analysis of the different selection methods used by farmers in the PPB program, please refer to our Farmer Selection Methods Research Brief.

PPB wheat plots at the University of Alberta.
Photo credit: @talonstokesphotography.

TABLE 5

Trends in traits of interest for wheat and oat farmers in Canada conducting PPB, split up by region.

Adapted from Jensen, Storosko, & Dang (2024).

Region	Traits of interest
British Columbia	Grain size
Prairies	Grain size, but also disease resistance, weed competition, and early establishment
Ontario	Agronomic traits related to production (like straw height, vigor, strength)
Quebec	Disease resistance
Maritimes	Agronomic traits related to production, yield, and disease resistance

Many farmers have developed their PPB grain populations to the point where they wish to commercialize them as seed and grain.[35] Despite this, in order for most major agricultural grain crops, including wheat and oats, to be distributed as seed or sold through licensed grain elevators, they must be registered through Canada's variety registration system. Successfully registering a variety involves undergoing a public process of peer-reviewed evaluation to ensure that said variety performs as well as or better than other registered varieties. The variety registration system is a critical element of Canada's seed system that ensures good quality seed of field crops are available for Canadian farmers; however, the process is too lengthy, expensive, and resource-intensive for farmers to participate.

Another barrier to registration of farmer-bred lines is that the required trials typically take place at centralized research stations where conventional agricultural practices are used. This inherently contradicts with the farmer-bred and organically-managed environments and goals in which PPB lines have been developed. These regulatory challenges have hindered establishment of distribution pathways for wheat and oat material developed through the PPB program.

Despite these challenges, farmers engaged in the PPB program have continued to make selections on their farms and pursued direct markets for their materials such as milling on-farm, selling direct to bakers, or selling their grain through a Community Supported Agriculture model. For a thorough analysis of the value chain opportunities and challenges experienced by growers in the PPB program, please see our Value Chain Discovery of Canadian Participatory Plant Breeders Research Brief.

Regardless of what stage these farmers are at in the PPB process, growers can benefit from receiving comparative agronomic data on PPB populations. As part of the *Climate-Resilient Seed Demonstration Site Project* and in collaboration with the University of Manitoba, we supported a range of multi-site replicated variety trials on farmer-bred PPB wheat and oat populations to evaluate their agronomic performance under organic growing conditions. These trials provide farmers with the opportunity to directly compare the performance of their PPB materials with those of other farmers' and registered check varieties. While the trial data collected is not eligible to be used to move these materials through Canada's variety registration process, trial data can inform farmers about whether their varieties need further improvement or perform comparably to other varieties.

[35] Jowett & Dang, 2024

PPB plots at the University of Alberta.
Photo credit: @talonstokesphotography.

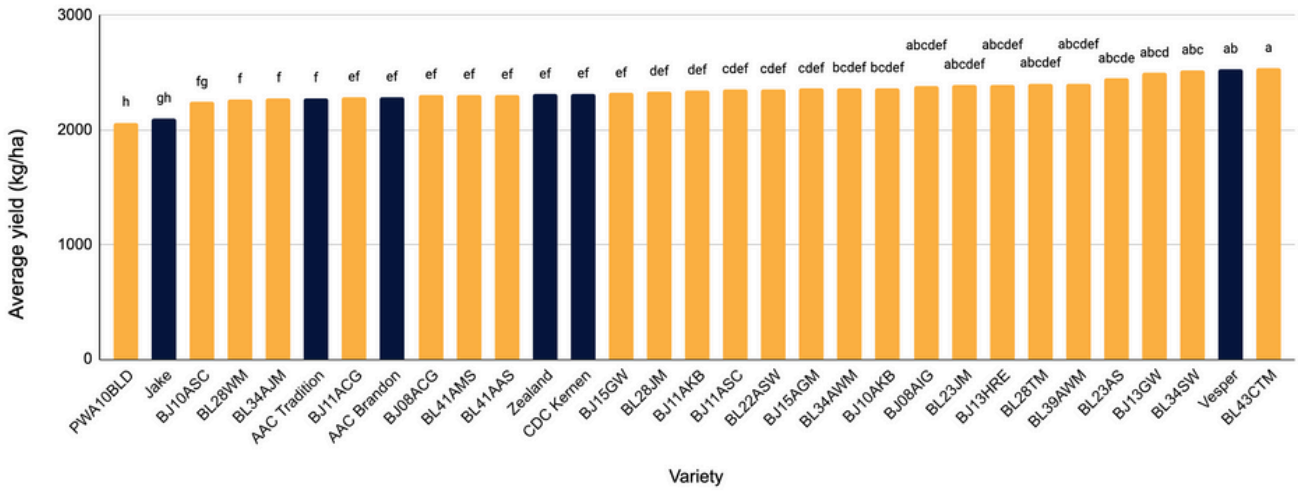
PPB Wheat

The University of Manitoba set up trials to evaluate 25 lines of farmer wheat populations to six check varieties of wheat across seven organic environments over three years (2020-2022). Results showed that variety had a significant effect on yield, with farmer varieties often yielding more compared to check varieties (**Figure 3; Table B1**).[36] BL43CTM, a farmer-bred variety, yielded significantly more than all other varieties. While the farmer variety, PWA10BLD, was one of the lowest yielding varieties, it still performed similarly to one of the check varieties, Jake. Results indicated that farmer lines were significantly taller on average compared to check varieties (**Table B2**). The increased height of farmer-bred varieties provides natural weed suppression, reducing the need for chemical or mechanized weed management.

FIGURE 3

Estimated average means (Lsmeans) for the yield (kg/ha) of 25 spring wheat farmer varieties and six registered checks across seven organic environments grown in 2020, 2021, and 2022.

Farmer lines are depicted with orange bars and check varieties are depicted by black bars. Values with differing letters signify varieties with significantly different yields, with the letter "a" indicating the greatest value, and so on. Adapted from Carkner (2024).



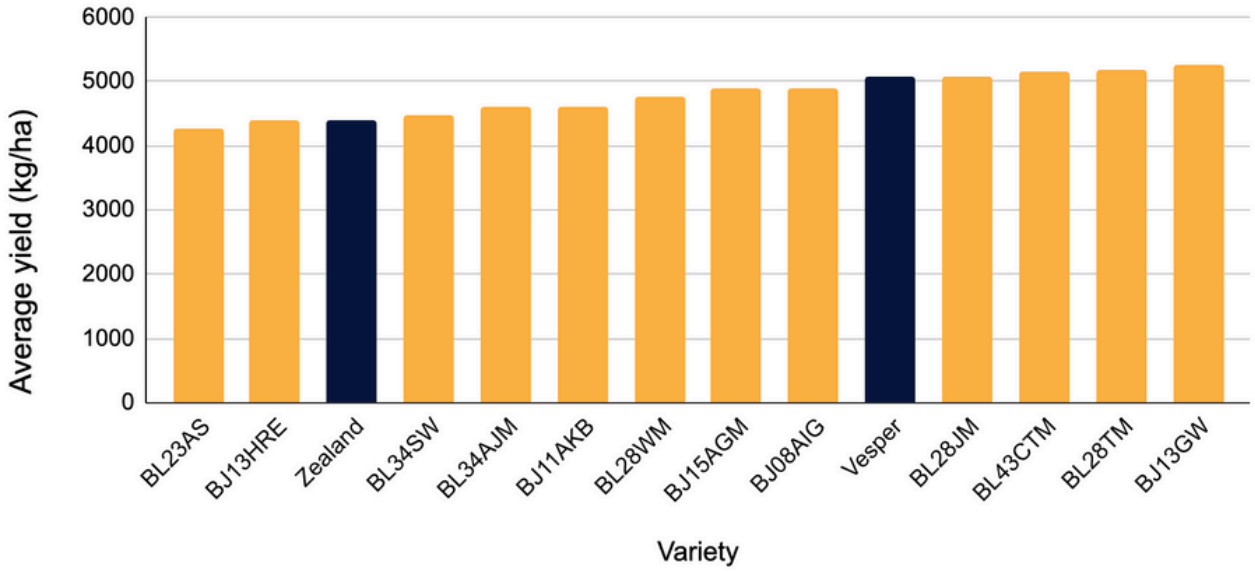
The Bauta Initiative also conducted a complementary PPB wheat trial where we evaluated 12 farmer varieties alongside two check varieties across two sites over two years (2022-2023). We found that variety had no effect on average yield, although this likely is due to our smaller sample size. Regardless, we found certain farmer-bred wheat varieties yielded higher on average compared to check varieties, mirroring findings from Carkner (2024) (**Figure 4; Table B3**). More results of these complementary trials can be found in **Appendix B** (**Table B4, Table B5**).

[36] Carkner, 2024

FIGURE 4

Average yield of farmer PPB and check wheat varieties trialled at MARA and UofA in 2022 and 2023.

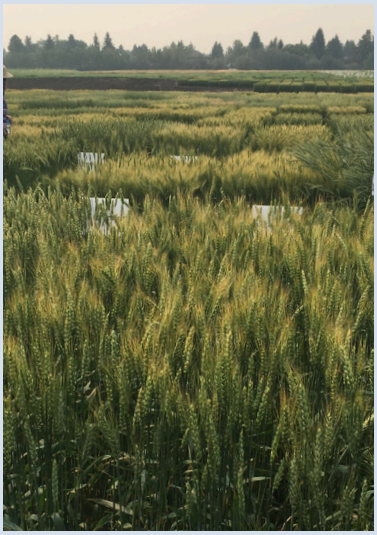
Yield was averaged across all site years, with each variety grown in four replicates. Farmer lines are depicted with yellow bars and check varieties are depicted by black bars.



The results from the combined wheat trials align with those reported in the published academic literature on the agronomic performance and characteristics of Canadian PPB wheat populations. When running multi-site and multi-year evaluations from farmer wheat lines produced out of the PPB program, the University of Manitoba found that after only three rounds of selections, farmer lines as a group yielded more on average than check varieties. They also found that farmer wheat selections were taller and later maturing, although more susceptible to lodging than checks. Farmer lines showed wide variation in their disease resistance, weed competitiveness, and other agronomic traits.[37]

[37] Entz et al., 2018

Farmer Stewart Well's PPB wheat population. *Photo credit: Sarah Preston.*



Stewart Well's PPB Wheat

Regionally-bred, regionally-adapted, regionally-produced

Stewart Wells and Terry Toews run Penny Lane Organic Farms, a certified organic 3,500 acre farm just outside of Swift Current, Saskatchewan. For the last ten years, Stewart has been selecting and increasing volume for various of his own hard red spring wheat (*Triticum aestivum* L.) lines to put forth for quality testing.

While Stewart's short-term goal with PPB is to breed high-quality organic wheat, his long term goal is to use on-farm plant breeding to help create a more democratic seed system. He believes that PPB can empower farmers to access high quality, diverse germplasm to reduce reliance on corporate seed companies that have historically monopolized the seed market.

Stewart's BL22A15-SW is currently one of his Hard Red Spring Wheat lines being evaluated in B-level variety registration trials in the Prairies. While going through variety registration trials is a long, rigorous, and expensive process, he hopes that getting his variety registered will offer organic farmers better seed and germplasm to work with.

TRAITS OF INTEREST

adapted to organic management, high yielding, disease resistance

DEMONSTRATION SITE

Mackenzie Applied Research Association - Fort Vermilion, AB

SEED PROVIDER

Stewart Wells at Penny Lane Organic Farms - Swift Current, SK

According to Stewart: “I think the most important thing that the PPB system could do, in terms of becoming an insurance system against monopolization by the private trade, is actually getting one or two varieties registered. That would be a tremendous feather in the cap of the whole system and it would provide an opportunity for farmers to freely exchange seed and sell seed to each other.”

Stewart Wells and Terry Stewart, 2019.
Photo Credit: Penny Lane Organic Farms.

PPB Oats

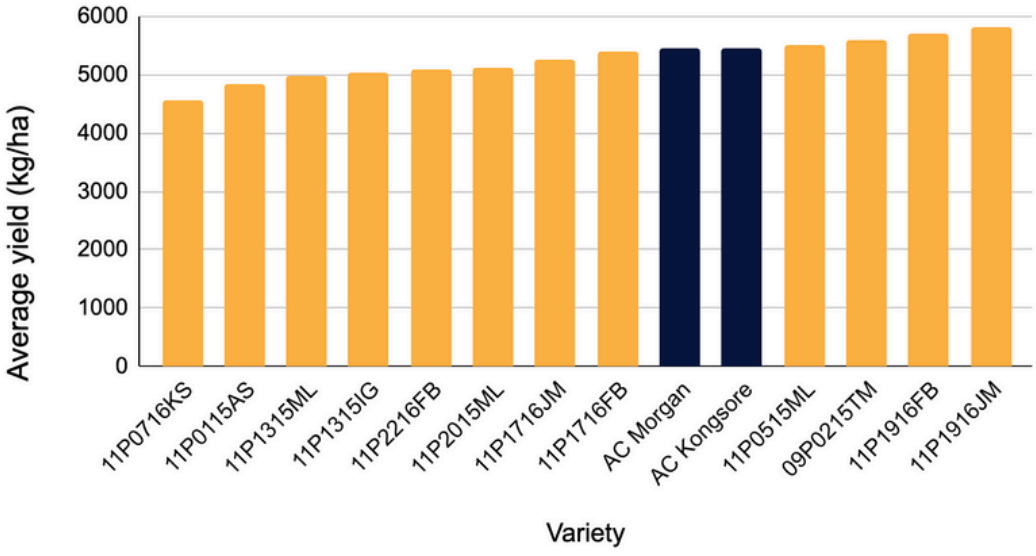
For the PPB oat populations, the Bauta Initiative conducted a variety trial over two years at Mackenzie Applied Research Association (MARA), where we evaluated 12 farmer varieties alongside two check varieties. We found that variety did not have a significant effect on yield across years, but within the small sample size, certain PPB lines surpassed the yields of check varieties (**Figure 5; Table B6**). Variety did have a significant effect on oat height, with farmer-bred oats being taller on average than check varieties (**Table B6**). Similar to the PPB wheat, farmers likely selected for taller oat varieties as a form of natural weed suppression. Farmer line, 11P1916JM, was overall the tallest and highest yielding of all varieties.

Farmer PPB oat varieties being trialled at MARA in Alberta in 2022.
Photo credit: Tierra Stokes.

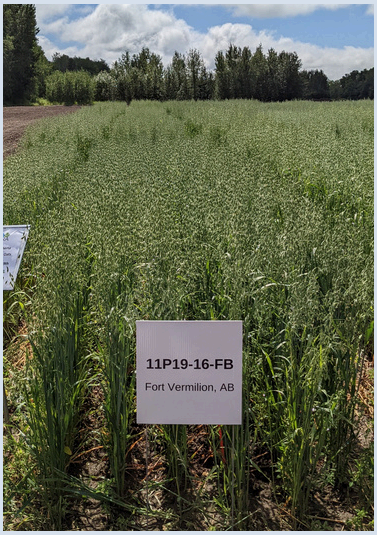
FIGURE 5

Average yield of farmer PPB and check oat varieties trialled at Mackenzie Applied Research Association (MARA) in 2022 and 2023.

Yield was averaged both years, with each variety grown in four replicates. Farmer lines are depicted with yellow bars and check varieties are depicted by black bars.



Farmer Frank Bueckert's PPB oat population. *Photo credit: Tierra Stokes.*



Frank Bueckert's PPB Oat

Regionally-bred, regionally-adapted, regionally-produced

Frank Bueckert, a grain farmer at Woodland Organics in Fort Vermilion, Alberta for the last 40 years, believes that "the future of farming is farmers adapting their crops to their own microclimate, and their own circumstances and situations."

Frank has participated in the participatory oat breeding program on his farm for four seasons, developing his own unique PPB oat (*Avena sativa*) variety, 11P1916FB. Frank specifically has been selecting this variety to be moderate in height, have upright growth, uniform maturity, and have well filled out heads with lots of seeds. His variety was evaluated in variety trials at MARA, where it performed competitively to other conventional and organic oat varieties.

According to Frank: "Every area of Canada is unique. And what grows good up here may not grow the same anywhere else and the other way around. And what I found out, especially in the organic industry, is that a lot of regulations are designed around southern climates. And so when we have to try to farm according to that up here it just doesn't work."

11P1916FB was one of the top-performing in the PPB program and is currently in AAFC's organic pre-registration trials where it is being grown at nine organically managed sites across western Canada. 11P1916FB has also advanced to the Western Cooperative Oat Registration Trial and is showing very similar performance to the popular oat variety, AC Morgan.

TRAITS OF INTEREST

reasonable height, upright growth, a well filled out head, plants with lots of seed on them, plants that mature at the same time

DEMONSTRATION SITE

Mackenzie Applied Research Association - Fort Vermilion, AB

SEED PROVIDER

Frank Bueckert at Woodland Organics - Fort Vermilion, AB

“The future of farming is farmers adapting their crops to their own microclimate, and their own circumstances and situations.”

- Frank Bueckert, grain farmer at Woodland Organics

Farmer Frank Bueckert at MARA in Alberta. *Photo credit: Tierra Stokes.*

Certain PPB lines of wheat and oat performed well enough in these trials to be adopted by public plant breeders to be included in pre-variety registration trials in 2023 and 2024. Although these trials are not being conducted in organic conditions, it will be exciting to see the results of how an organically-bred PPB line performs against conventionally-bred materials.

Zealand wheat growing at MARA.
Photo credit: Tierra Stokes.

The diversity and success seen in the PPB lines highlights how farmers can use PPB as a tool to develop grain varieties that suit their agricultural contexts. Further, farmers can save seeds from their PPB materials on their farms, giving them full control over their seed supply.

Similar to the successes of PPB programs all over the world, these examples further demonstrate how PPB can play an invaluable role in developing seed that is essential for long-term seed sovereignty and climate-resilient agriculture.

Farmer-Led Field Crop Adaptation

In addition to supporting farmers through the PPB program, field crop demonstration sites also featured varieties from field crop producers who are pursuing adaptation and breeding work independent of institutional support. The adaptation and breeding work done by farmers demonstrates the incredible ingenuity of the organic and ecological farming community, and should signal to public research institutions on the kinds of on-farm research to support.

For heirloom/heritage field crops specifically, there is an enormous opportunity to support the conservation and use of these types of field crops for the protection of agricultural biodiversity and seed sovereignty. Farmers are increasingly working to bring many of these varieties back into circulation and grow them for personal consumption, as well as community and commercial distribution.

The varieties showcased in this section are examples of heritage field crop adaptation and niche field crop variety development. All of these efforts – in addition to more institutionalized programs like PPB – are necessary in order to generate a continuous supply of diverse varieties of field crops to build climate resilience in agriculture.

Farmer gathering in the oat field at Ferme Céréalière Paquet in Quebec.
Photo credit: Hugo Martorell.

Dried Flood Fife.
Photo credit: Ironwood Organics.

Flood Fife Wheat

Regionally-adapted, regionally-produced, heirloom

TRAITS OF INTEREST

climate-resilient, flood-resilient

DEMONSTRATION SITE

Ironwood Organics - Athens, ON

SEED PROVIDER

Chris Wooding at Ironwood Organics - Athens, ON

Many seeds are only bred to grow in stable environmental conditions. As weather extremes have become more common across Canada, Chris Wooding at Ironwood Organics strives to adapt his wheat to be more climate-resilient.

In 2017, during a summer of repeated floods, Chris' populations of Red Fife (a heritage grain from 1844) and Winter Rose Red Fife, only managed to produce an 8% yield at 80lb per acre. Chris saved the seed that survived from this population and it formed the basis of what became his new flood-resistant winter wheat population, Flood Fife.

For the next couple years, Chris continued to plant seed from his Flood Fife in areas of his fields where flooding risk was high and saved seed from surviving plants. Last year, in spite of the flooding, his field of Flood Fife saw the highest yield grain at 2,300lbs per acre, grown organically and with no inputs. Wheat testing analysis showed that Flood Fife had comparable qualities to other wheats on the market milled for baking, and had negligible presence of mycotoxins.

Flood Fife currently performs predictably and is more stable across environmental conditions than other varieties Chris grows. Chris wants to trial growing Flood Fife in dry conditions over time to see if its flood tolerance qualities persist. He also wants to share his seed and grow Flood Fife at other regional farms to test its performance in other wet field environments.

Chris advocates for adapting seed through selection to extreme weather conditions as a key strategy to ensure future sustainable harvests, food sovereignty, and climate-resilient agriculture.

Flooded wheat fields at Ironwood Organics in Ontario. *Photo Credit: Ironwoods Organics.*

Tall Boy Oats: Composite Population

Regionally-adapted, regionally-produced

Dried Tall Boy oats in the field in Quebec. *Photo credit: Hugo Martorell.*

TRAITS OF INTEREST

weed competition, climate adaptation

DEMONSTRATION SITE

Club de gestion des sols du Témiscouata - Témiscouata-sur-le-Lac, QC

SEED PROVIDER

University of Manitoba - Winnipeg, MB

The PPB program commonly used a variety of oat called Tall Boy as a check variety for farmers to compare against in their oat selections; some growers observed that this variety grew well under organic conditions. When growers asked the University of Manitoba (UofM) to share Tall Boy oat seeds, they had no more stock and had little information on where stock was available. The U of M was eventually able to source Tall Boy oats from one local farm, and then sent it out to various farmers across Canada to observe on their farms.

In Quebec, agronomist Lise Dubé received 20kg of the seed and grew it out on different farms every year to select her oats for weed competition and climate adaptation to the local region. In 2023, she mixed together ⅘ from her Tall Boy population with ⅕ from her other oat populations to create a composite population. After growing this new population, she observed significant improvements: the oats were tall, yielded well, had great weed competitiveness, and had the preferred qualities that her oat processor customers were looking for.

Many farmers in the PPB program made similar decisions to make composite populations with the materials they received. This approach creates resilient populations that have a greater diversity of traits that can help protect crops against seasonal variations in conditions.[38] Composite populations can also help bulk up seed quantities, increasing seed security when seed availability is limited. Lise's experience is representative of the work that is being done globally on developing evolutionary populations for climate resilience.

[38] Murphy, Carter, & Jones, 2014; Garrett & Mundt, 1999

Composite Tall Boy oat field at Club de gestion des sols du Témiscouata in Quebec. *Photo credit: Hugo Martorell.*

Nikian 21 rice drying in the greenhouse at Nikian Farms in Nova Scotia.
Photo credit: Natalie Walker.

Nikian 21 Rice

Regionally-bred, regionally-adapted, regionally-produced

Niki Clark and Ian Curry of Nikian Gardens have been growing paddy rice (*Oryza sativa*) ecologically for the last 10 years. For them, rice is a solution to the problem of food insecurity and food import dependence in Nova Scotia. A highly adaptable crop and well suited to small plots and marginal lands, rice is a highly productive grain crop that does not require heavy duty farm equipment or milling and can contribute meaningfully to household and community food security.

In 2021, Niki and Ian created a small, mixed patch of rice containing roughly 10 different rice varieties, and came across a "sport" (or mutant) with superior morphological characteristics including height, bigger seed heads, and fuller seeds than its counterparts. Impressed by its potential, they developed a breeding population from this plant, naming it, Nikian 21. So far, the resulting plants have demonstrated an incredibly rich diversity of offspring giving great potential to select for desired traits, or more likely, selecting to maintain its wide diversity as a climate adaptation strategy.

According to Niki: "What I will be selecting for personally is hurricane resistant rice, I guess what that looks like is short and wind-tolerant, something that's not going to blow over during the hurricanes that we have. [Also] something that is also going to produce lots of seeds and nice fat seeds that this variety seems to have... These lend itself to some of our developing challenges with climate change."

According to Ian: "We've got a lot of genetic diversity in this one plant's offspring and we'll continue to grow it out as indiscriminate, we did not select for anything. And then we'll start to think about what we'd like to select for. I'd definitely go for big, fat heads of rice with big fat seeds. This seems to have great potential for a very productive variety of rice. We're tentatively calling it Nikian 21 because it came from our 2021 crop experiments."

TRAITS OF INTEREST

Niki - hurricane-resilient, wind-tolerant, short, big seeds, genetic diversity;

Ian - big/fat heads, fat seeds, genetic diversity

DEMONSTRATION SITE

Nikian Gardens - Granville Beach, NS

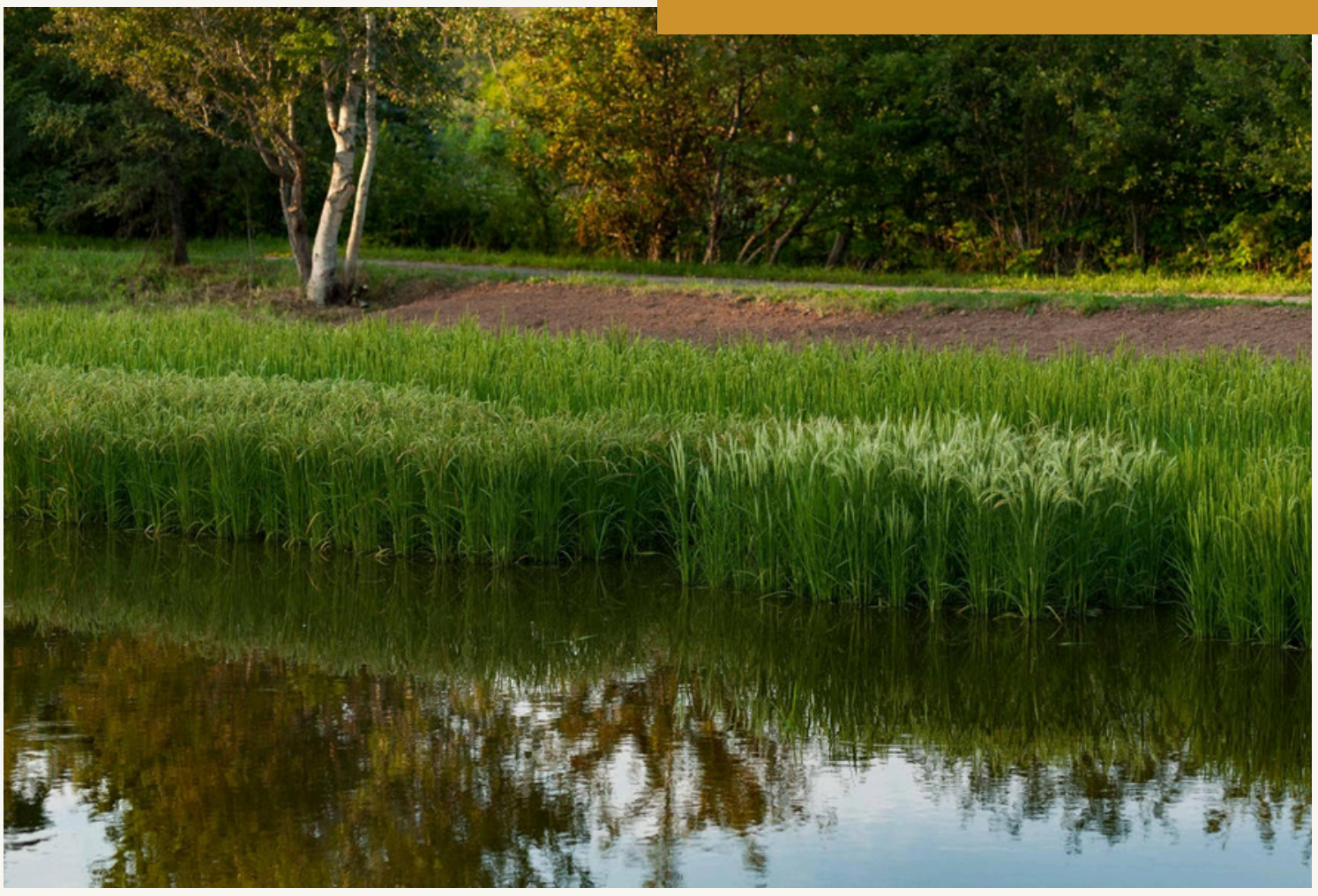
SEED PROVIDER

Nikian Gardens - Granville Beach, NS

"What I will be selecting for personally is hurricane resistant rice, I guess what that looks like is short and wind-tolerant, something that's not going to blow over during the hurricanes that we have. [Also] something that is also going to produce lots of seeds and nice fat seeds that this variety seems to have... These lend itself to some of our developing challenges with climate change." - Niki Clark

We hosted a virtual Field Day at Nikian Gardens! Check out this video to learn more about how Niki and Ian work to grow, breed, and save seed from paddy rice!

Paddy rice fields at Nikian Gardens in Nova Scotia. *Photo credit: Garth Laidlaw*



Perennial Grains

Perennial crops have always been an important element in the design of climate-resilient crop rotations, offering benefits like reduced soil tillage, year-round soil coverage, decreased agricultural runoff, and habitat for various organisms.[39] However, increased fluctuations in wintertime temperatures, snow cover, and precipitation due to climate change is drastically changing the use of perennial field crops in Canadian agriculture. Plant hardiness, winter injury to crops, and soil organic carbon are all expected to be impacted by these fluctuations.[40]

Accordingly, the crops highlighted in this section represent efforts farmers and plant breeders are taking to evaluate suitability of perennial crops in organic and other climate-resilient farming systems.

Left: A field of established switchgrass at Bishop's University in Quebec. *Photo credit: Bishop's Educational Farm.*

Right: Flowering Kernza® at Bishop's University in Quebec. *Photo credit: Bishop's Educational Farm.*

[39] Culman et al., 2013; Jungers et al., 2023; Wang et al., 2020
[40] Lychuk et al., 2019; Qian et al., 2024

Switchgrass Organic Establishment Trial

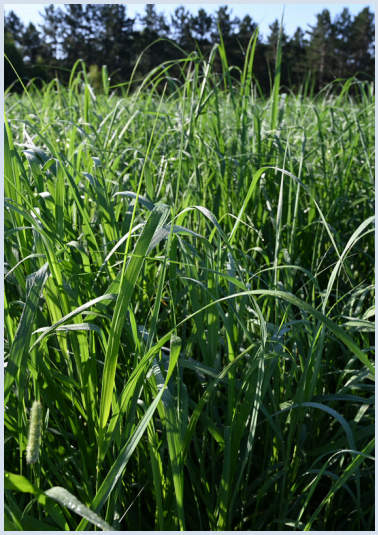
Regionally-bred, regionally-produced, candidate for regional production

Switchgrass (*Panicum virgatum*) is a tallgrass prairie species native to the American midwest with many potential end uses including ecological restoration, fibre, biomass, livestock fodder, and cellulosic ethanol. For the last 30 years, Resource Efficient Agricultural Production (REAP)-Canada has been breeding "upland" switchgrass, which is an ecotype of switchgrass adapted to Canada's shorter growing seasons and colder winters. Despite this, establishing a perennial stand of switchgrass can be challenging due to weed competition, which has prevented widespread adoption by farmers.

In a collaborative effort between the Bauta Initiative, REAP Canada, and Bishop's University's Sustainable Agriculture and Food Systems program in 2021-2023, researchers ran an organic variety trial to assess the establishment success of eight upland switchgrass varieties (**Table 6**). The trials focused on traits linked to weed competition during stand establishment, including establishment rate, plant height, and canopy closure.

RC Big Rock II. Photo credit: Bishop's Educational Farm.

Switchgrass growing at Bishop's University in Quebec. *Photo credit: Bishop's Educational Farm.*



TRAITS OF INTEREST

weed suppression, establishment potential

DEMONSTRATION SITE

Bishop's University - Sherbrooke, QC

SEED PROVIDERS

Ernst Conservation Seeds - Meadville, PA

Resource Efficient Agricultural Production (REAP) Canada - Sainte-Anne-de-Bellevue, QC

TABLE 6

List of upland switchgrass varieties evaluated in this trial, alongside who bred them and who provided seeds for this trial.

"N/A" (not available) denotes varieties with unknown breeders.

Variety	Breeder	Seed Source
Summer	N/A	Ernst Conservation Seeds
RC Tecumseh II	REAP Canada	REAP Canada
Cave-In-Rock (Check)	N/A	Ernst Conservation Seeds
RC Big Rock II	REAP Canada	REAP Canada
RC Chippewa	REAP Canada	REAP Canada
RC Sundance	REAP Canada	REAP Canada
RC Sundance II	REAP Canada	REAP Canada
RC Blue Jacket II	REAP Canada	REAP Canada

Based on the first year of establishment in 2021, RC Sundance II demonstrated the best early vigor as it had the greatest and rapidly establishing height and canopy cover, but it had the worst lodging by the end of the season. When considering the 2022 and 2023 data, all REAP-bred switchgrass varieties performed better than control varieties across all agronomic measures of height, leaf width, and lodging, with no REAP varieties clearly outperforming other REAP varieties. Overall, researchers felt that RC Chippewa demonstrated the most balanced and consistent performance, with it repeatedly having above-average high height, wide leaf width, low lodging, and high yield.

Site managers observed similar weed pressure across varieties, especially from perennial weeds like thistle. They found they were able to greatly reduce weed pressure by strategically weeding the switchgrass plots after spring harvests, indicating that cultural practices play a significant role in reducing weed pressure for perennial grasses.

REAP-Canada welcomes collaborations with growers and researchers to establish best practices in cultivating switchgrass across Canada. Such initiatives not only support switchgrass breeding programs, but also address the crucial need for agronomic information on successfully cultivating switchgrass under organic and ecological, on-farm conditions.

Interested in knowing more about how different switchgrass varieties compared to each other? Read the full trial report here!

Kernza® Intermediate Wheatgrass Organic Establishment and Intercropping Trial

Candidate for regional adaptation

Kernza® intermediate wheatgrass (*Thinopyrum intermedium*) is a perennial grain that can be grown for both forage and feed. Originally developed by researchers at the Land Institute in Kansas, the perennial growth habit and deep root structure of the plant protects soil structure and prevents nitrogen leaching into local waters.[41] Kernza® has only recently been adapted for agricultural use, and perennial grain crops are not a traditional component of climate-resilient crop rotations. Kernza® has immense potential for food security as its perennial nature can provide continual harvests that require less resources for its cultivation compared to other annual grains.

The University of Manitoba has a Kernza® breeding program in the Prairies that focuses on breeding Kernza® to be adaptable to regional challenges like drought and compatible with diverse crop rotations. Comparatively, little research has been done on Kernza® performance in other regions of Canada. Farmers and researchers were therefore interested in running trials in other regions to better understand Kernza's® potentials for organic cultivation and regional adaptation. At Bishop's University in Sherbrooke, Quebec in 2021, researchers established a Kernza® trial using seed provided by the University of Manitoba. This trial observed the effect of different row spacings (12" and 24") and different legume intercrops (Crimson clover from Johnny's Selected Seed, Zenith black bean from Veseys Seeds, and Windsor fava bean from West Coast Seeds) on Kernza® establishment.

Kernza® growing at Bishop's University in Quebec. *Photo credit: Bishop's Educational Farm.*

TRAITS OF INTEREST

intercropping potential, establishment potential, weed suppression

DEMONSTRATION SITE

Bishop's University - Sherbrooke, QC

SEED PROVIDERS

University of Manitoba - Winnipeg, MB

Johnny's Selected Seed - Winslow, ME

West Coast Seeds - Delta, BC

Veseys Seeds - York, PEI

[41] Culman et al., 2013

Table 7 summarizes how well Kernza® plants were established when grown at different spacing and intercroppings following a spring planting. Researchers ran multivariate ANOVA analysis on the effect of treatment on establishment measures and found that there were no significant differences between treatments. After checking on the Kernza® plants post-trial in 2023, site managers anecdotally found plants in different treatments lodged to varying degrees. They also noticed that in the spring when Kernza® regrows and in the late summer/early fall after harvest when Kernza® dies back, weeds quickly establish in the field, making weed management difficult.

TABLE 7

Measures of Kernza® establishment and lodging at different row spacing (inches) and intercropping treatments.

The average number of plants established per block was determined by placing a 1x1m sampling square (subdivided into 25 cells) in three random areas of each treatment, and counting how many cells contained at least one plant. Average canopy heights and widths were measured by averaging measurements from nine randomly selected plants within each treatment.

Treatment	Average # of blocks with +1 plant	Average canopy height (cm)	Average canopy width (cm)	Degree of lodging
12" Kernza®	9.3	6.5 ± 2.1	7.7 ± 3.2	Extreme
12" Kernza® + clover	10.3	7.6 ± 2.5	7.5 ± 2.1	Mild
24" Kernza®	12.3	5.0 ± 1.6	4.6 ± 0.7	Mild
24" Kernza® + black bean	8.0	5.8 ± 0.7	5.5 ± 0.4	None
24" Kernza® + fava bean	8.7	6.9 ± 1.1	7.6 ± 1.0	Extreme

The lack of significant results suggests that Kernza® may be intercropped with other plants without risk of lowering plant establishment. However, while intercrops should help with weed control during establishment in the first year, weeds may proliferate during following years if weed pressure is high.

Kernza® intercropping provides a great opportunity to plant crops that not only maintain soil health, but also create habitat for insects and produce economic products. The University of Manitoba's Kernza® breeding program is open to collaborating with growers to explore Kernza's® performance in regions across Canada, and work towards adapting Kernza® to a wider range of Canadian climates. As Kernza® variety trialling and best practices develop further, this can increase the accessibility and adoption of Kernza® seed among organic, ecological, and regenerative organic growers.

Want to know more about the results of this trial? Check out the full report here!

Siri van Gruen, demonstration site manager at Abbotsford Research and Seed Education Farm in British Columbia, harvesting dried plants for seed production. *Photo credit: FarmFolk CityFolk.*

Changes in Farmer Seed Saving Behaviour

Changes in Farmer Seed Saving Behaviour

In 2023, in collaboration with Good Roots Consulting, the Bauta Initiative administered a survey to program participants to learn about the experience of farmers engaged in our program.

The majority of farmers who completed the survey engaged with the demonstration sites either by contributing varieties or participating in a field day/workshop/virtual training event related to the work of the sites. Accordingly, we surveyed farmers on the degree to which the collective activities of the Bauta Initiative impacted their on-farm seed saving practices, skills related to implementing variety trials and on-farm plant breeding, and willingness to procure more regional seed.

Of the 146 farmers and seed growers who completed the survey, 55.5% are commercial vegetable growers, 34.9% grow seed for commercial sale, and 11.0% are field crop farmers. 73.5% of respondents farmed under 10 acres, and 26.5% had over 10 acres in active production. Of these growers, 63.7% grow seed for their own use.

Researchers and students harvesting Kernza® at Bishop's University in Quebec. *Photo credit: Bishop's Educational Farm.*

Below is a summary of the degree to which they have **experienced changes in their seed saving skills and their access to seed diversity** through participating in our program.

Results are presented according to the number of people who responded to each particular question. Some respondents chose not to answer every question or indicated “not applicable” for questions that did not relate to the specific way that they had engaged in the program.

VARIETY TRIAL ABILITIES:

83.7% improved their abilities related to organizing and implementing variety trials. (n = 135)

PLANT BREEDING SKILLS:

74.4% improved their abilities related to plant selection, variety improvement and/or on-farm plant breeding. n = 125)

SAVING DIVERSE SEED:

66.4% were saving a greater diversity of vegetable or field crop seed. (n = 113)

SEED QUALITY:

75.9% were saving better quality seed. (n = 116)

ACCESSING DIVERSE SEED:

71.2% were able to access a greater diversity of regionally adapted, ecologically-grown seed. (n = 125)

PURCHASING MORE REGIONAL SEED:

60.2% were purchasing more regionally adapted, ecologically-grown seed. (n = 123)

INTEREST IN PRODUCING SEED UNDER CONTRACT:

59.2% had a greater interest in producing seed under contract. (n = 113)

SELLING SEED:

41.0% had started to sell seed commercially. (n = 78)

Angie Koch, owner of Fertile Ground Farm, leading a field day of the demonstration site hosted at her farm in Ontario. *Photo credit: Laura Northey*

These survey results indicate that the interventions of demonstration sites, when accompanied with a suite of learning opportunities, **can be effective at positively impacting the seed saving and seed procurement behaviour of farmers.**

Farmers are interested in developing more capacity for on-farm seed production and plant breeding, but are risk-averse when considering incorporation of commercial seed production into their business. Farmers also shared the ways in which this program has influenced their understanding or procurement practices around regional seed. Many noted that the knowledge shared through the Bauta Initiative about the importance of regional seed increased their seed literacy and regional seed procurement. Below are a sample of quotes from survey respondents outlining how the Bauta Initiative has influenced their engagement and perspectives on regional seed, split up by theme:

Incorporating more on-farm seed saving:

"**Far more market/vegetable farmers in Atlantic Canada are growing seed now than they were 10 years ago.** I think a lot of that is from knowledge/confidence gained from Bauta events. From our perspective, this means a lot more options to source local seed to offer to the public through [our seed company]."

"It was the Bauta Initiative that encouraged and supported me in saving seed for the first time. Since then they have been there every step of the way to support, train, and connect me with other seed savers/new opportunities/resources. **I now grow 75% of the seed I use on my farm, supply seed to my community, sell seed on contract to other regional seed companies, sell my own retail seed packets, and have begun dabbling in breeding.** None of this would be true were it not for Bauta. It sounds dramatic, but literally, the Bauta Family Initiative on Canadian Seed Security has changed my life in a wonderful way."

"I put much more emphasis on **having a seed crop alongside my market garden**, every year learning from the practice of saving seed from a new crop."

Procuring more regional seed:

"**Running a trial site gave us a huge opportunity to trial local seed and better still showcase them to the community**. We will be growing many of the same varieties this season."

"Through its work promoting regionally adapted seed in BC, the Bauta Initiative has definitely given me **the confidence to support more local seed growers**, with the confidence I will receive high quality seed."

« Cette expérience **a confirmé nos choix de faire affaire avec des semenciers les plus locaux possible**. C'est un art être semencier! » "This experience confirmed our choices to do business with seed companies that are as local as possible. It's an art to be a seed grower!"

Fava bean seeds being planted at Abbotsford Research and Seed Education Farm in British Columbia. *Photo credit: FarmFolk CityFolk.*

Increased farmer knowledge related to seed production:

« [L'initiative Bauta aide avec] une meilleure structure des parcelles d'essais, et m'a sensibilisé à l'importance de mieux évaluer les différentes caractéristiques des variétés à l'essai afin de mieux cibler celles qui sont choisies pour les années futures. » “ [The Bauta Initiative helped with] better structure of the trial plots and **made me aware of the importance of better evaluating the different characteristics of the varieties** being tested in order to better target those that are chosen for future years.”

« [L'initiative Bauta aide] principalement par les vidéos partagées sur la chaîne Youtube. Très bon contenu pour bien diriger la sélection végétale, et l'intervention de sélectionneurs/hybrideurs est très pertinente. Et aussi les essais de cultivars, très intéressants pour diriger nos choix. » “[The Bauta Initiative provides help] through videos shared on the Youtube channel. **Very good content to properly manage plant selection, and the intervention of breeders/hybridizers is very relevant.** And also the variety trials, very interesting to direct our choices.”

“Through the Bauta Initiative I have been on educational field trips to seed houses to learn the ins-and-outs of commercial seed production, and through speakers at [the ACORN Conference] I have heard speakers on many seed topics, so **my knowledge on seed production has increased immensely.**”

An overwhelming majority of respondents were also able to **access shared knowledge and community connection** through our programming, addressing the need among farmers for more learning, training, and social opportunities.

85.3% had shared or received ideas and knowledge related to seed production and plant breeding with other farmers; and,

84.3% felt more connected with other farmers and seed growers who are part of the seed movement in Canada

Plant material being run through FarmFolk CityFolk's mobile seed cleaning thresher. *Photo credit: FarmFolk CityFolk.*

These survey results indicate that demonstration sites facilitated important connections between farmers and others across the agricultural industry.

Farmers mentioned how the program facilitated network building with industry collaborators at both regional and national levels, which provided valuable support for their agricultural work, even beyond seed. Farmers also emphasized how this program has helped them connect with a community of individuals with similar interests, allowing them to lean on each other for social connection, learning, and agronomic support. Below are a sample of quotes from survey respondents related to how connections made within the community have influenced their attitudes and behaviours related to seed:

"[The Bauta Initiative helped with] connecting to other farms and **bringing some scientific rigour to what is otherwise very independent work.**"

« L'initiative Bauta a joué un rôle central dans la solidification des liens entre les différents acteurs du milieu. J'ai le réel sentiment de faire partie d'un réseau de semenciers au Québec. » "**The Bauta initiative played a central role in solidifying the links between the different actors in the sector.** I have the real feeling of being part of a network of seed companies in Quebec."

"The Bauta Initiative has helped link us with other local plant breeders and **these connections have resulted in us offering new seed varieties in our catalogue**."

"Our engagement in the Initiative has helped enmesh us into a social fabric of farmers and breeders with shared interests. **We are able to make face-to-face connections and share ideas and knowledge more freely.**"

« Nous avons réseauté avec d'autres fermiers ou semenciers. Nous avons développé un intérêt à la production de semences, ou du moins d'être auto-suffisant en semences pour nos productions maraîchères. » "We networked with other farmers or seed companies. We have developed an interest in seed production, or at least **being self-sufficient in seed for our market gardening**."

"Before I joined I was always interested in ecologically grown veg and fruits coming from Sri Lanka. I felt like I was alone learning what I could. **Now I feel connected and have a group that I can rely on for information and support.**"

"I doubt I would have my own small seed company now (PEI Seed Alliance) without the knowledge gained through Bauta. I wouldn't have had the hands-on experience gained through the farmer seed network, plus the help to access good seed from our Maritime Seed Bank & Seeds of Diversity. Steph Hughes, our Maritime [Coordinator] is always there to help & guide us. Bauta has trained & supported all of our seed interests & initiatives, plus **made us proud to be part of a vitally important seed community** that is fighting to feed Canadians now and in the future as we adapt to climate change."

Seedlings growing at Abbotsford Research and Seed Education Farm in British Columbia. *Photo credit: FarmFolk CityFolk.*

CONCLUSION:

Building Climate-Resilient Seed Systems in Canada

Seeds are the foundation of agriculture, and seed diversity is critical to the success of climate-resilient farming systems.

Climate change poses a significant threat to Canada's agricultural sector, signalling the need for adopting agricultural practices that will mitigate emerging environmental challenges. Organic, ecological, and regenerative organic farming systems offer promising solutions, not only in reducing greenhouse gas emissions but also in providing ecological benefits that are essential in fostering climate-resilient agriculture.

Farmers understand the enormity and complexity of these challenges. As farmers adopt more climate-resilient farming practices, they need a wide diversity of regional seeds that are well-adapted to those conditions. By showcasing and evaluating these kinds of varieties, the demonstration sites we manage help fill a critical gap for this community of growers. These sites provide opportunities to gather valuable multi-site agronomic data about varietal performance and create a dynamic space for knowledge sharing about climate-resilient seed systems.

As evidenced by the diversity of varieties showcased in this report and by the impacts these sites have had on the farming community, there is tremendous potential in building Canada’s domestic organic and ecological seed system. The sites have already contributed to greater awareness of the importance of regional seed systems and new commercialization opportunities for regional seed.

The varieties showcased in this report and those featured at the demonstration sites are only a small sample of the remarkable seed saving and plant breeding efforts of organic and ecological farmers. For gardeners, farmers, and researchers interested in seeing the full diversity of seed being grown in Canada, please visit **weseedchange.org/local-seeds**.

Demonstration sites have also helped catalyze PPB and PVS collaborations between researchers, agricultural organizations, and farmers. Some major outcomes of this work include:

- Due to the success of the organic carrot breeding work and the national-scale variety trials facilitated by CANOVI, our vegetable breeding and trialling collaboration with UBC is entering its second phase with an expanded crop focus for another four years.

- In Ontario, interest in our participatory research methodology initiated a collaboration with researchers from AAFC interested in developing new dry bean varieties for organic farming systems.

- In Quebec, the Bauta Initiative is in the process of continuing a PPB potato breeding program with Consortium de recherche sur la pomme de terre du Québec (CRPTQ) and Bishop's University, exploring collaborations with McGill University on incorporating organic trials into their pulse breeding program, and working with the Centre de recherche sur les grains (CEROM) to explore the potential of PPB for buckwheat and sunflowers.

- In the Prairies, the materials developed through the PPB wheat and oat program are being incorporated into other research projects on organic agronomy. Many farmers are eager to continue the selection work, start new plant breeding projects on different crops, or work with different researchers to explore moving more materials through the variety registration system.

These developments are positive signs in the climate-resilient farming sector, but significant gaps remain. Whether it is a small-scale vegetable seed company developing unique, regional varieties, or a diversified grain farm developing a new variety of wheat requiring evaluation in climate-resilient farming conditions, farmers and seed growers continue to bear the economic burden of regional seed development for this sector.

These activities contribute to the public good through the preservation and creation of significant agricultural biodiversity. To ensure this work can continue and scale up, farmers and seed growers require more public support.

Federal investment in organic and ecological variety development pales in comparison to the public resources available to conventional plant breeding. Over the past decade, approximately $3M in public funding has been allocated to organic vegetable and field crop development (of which SeedChange has contributed $500,000).[42] A recent study by the University of Saskatchewan indicated that approximately $14.8M of annual public funding is invested into conventional wheat breeding alone.[43] Accordingly, there is an enormous opportunity for public research institutions and the federal government to build on the momentum of this community with strategic investments.[44]

[42] Data compiled from all listed plant breeding projects supported through Organic Science Clusters 2013-2023. OACC, 2024
[43] Bolek-Callbeck & Gray, 2022
[44] Lyon, Friedmann, & Wittman, 2018; Kröbel et al., 2021

Although farmers are appreciative of the efforts of the Bauta Initiative, they also acknowledge the public interest component of this work and the limits of what can be accomplished through the scale of our organization:

"I'm a bit frustrated that the [Bauta Initiative] has to exist, and that it does exist as a separate entity [from the government]. Because it's no substitute [or] an adequate replacement for public research in my view...I think they do an amazing job given [the] funding that they do have...But it really should be a government funded program. And that should be a part of the broad public interest research."

The federal government is in the process of setting ambitious targets to reduce GHG emissions from agriculture. Investing in regional seed systems, as articulated in this report, will help farmers adopt and maintain the climate-resilient farming practices *required* to meet those targets. These investments also help Canada meet its international public policy commitments (e.g. International Treaty on Plant Genetic Resources for Food and Agriculture) through supporting the sustainable use and development of plant genetic resources through farmer-led seed conservation, production, and plant breeding.

Farmers and seed growers in the organic and ecological farming community have been leading seed adaptation and plant breeding work long before the interventions of the Bauta Initiative, and will continue to do so with or without support. But in order for this work to truly scale – to extend beyond the climate-resilient farming community – and generate the kind of ecological benefits Canadian agriculture needs, more investment is needed from the federal government.

Organic, ecological, and regenerative organic farmers in Canada are working to preserve, improve, and create new seed diversity to advance climate-resilient seed systems and contribute to the future resilience of our food systems.

For these growers to continue to do this important work, they need an enabling public policy landscape that supports their efforts. We hope that the successes of this partnership with AAFC demonstrate the potential of this sector, and signal the kind of research and public policy investments required to build robust, farmer-led, climate-resilient seed systems in Canada.

Learn more!

For more information on ways to get involved in the Bauta Family Initiative on Canadian Seed Security, please visit **seedsecurity.ca**.

If you would like to learn more about any of the crops and varieties featured at these demonstration sites, or how to get more involved in the seed community in Canada, please contact the Regional Coordinators of the Bauta Initiative:

ATLANTIC CANADA:
Steph Hughes, SeedChange
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Peas growing at La Radicule in Quebec. *Photo credit: Sophie Bourdon.*

If you are a research organization interested in collaborating with the Bauta Initiative, we encourage you to review our list of participatory research and knowledge transfer services **here**.

If you have any questions about this report, please contact **Aabir Dey (adey@weseedchange.org)**, Director of The Bauta Family Initiative on Canadian Seed Security at SeedChange.

Rice being hung up to dry at Nikian Gardens in Nova Scotia. *Photo credit: Stephanie Hughes.*

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Amaranth growing at Fertile Ground Farm in Ontario. *Photo credit: Laura Northey*.

APPENDIX A.

Summary of Demonstration Sites

TABLE A1

Vegetable Demonstration Sites

Full list vegetable crops grown at demonstration sites with collaborating seed providers, split up by region.

Region	Demo Site	Crops grown	Seed providers	Types of Plots
British Columbia	Abbotsford Research and Seed Education Farm	Amaranth, bean, broccoli, cabbage, carrot, corn, fennel, flowers, kale, lettuce, legumes, melon, onion, pea, pepper, potato, summer squash, winter squash, tomato, turnip	Adaptive Seeds, Annapolis Seeds, BC Eco Seed Co-op, Carrot Improvement for Organic Agriculture, Centre for Sustainable Food Systems at the University of British Columbia, Diggers Farm, Farm Glorious Organics Co-op, Fruition Seeds, Good Earth Farms, Hawthorn Farm Organic Seeds, La Société des Plantes, Metchosin Farm, Organic Seed Alliance, Saanich Organics, Sage Garden Greenhouses, Salt Spring Seeds, Scott Harris, Seeds of Diversity, Seeds of the Revolution, Sunshine Farm Seeds, Tourne-Sol Cooperative Farm, West Coast Seeds, Wild Rose Heritage Seed Company, Yonder Hill Farm	Screening/ observation trials, showcase garden, variety trial vegetable seed production plot
	Fraser Common Farm Co-op			
	Sandown Centre for Regenerative Agriculture			
	University of British Columbia Farm			
Prairies (Alberta, Saskatchewan, Manitoba)	Peno Creek Farm	Amaranth, arugula, bean, beet, borage, carrot, chard, cilantro, cucumber, dill, kale, millet, pea, radish, spinach, summer squash, sweet potato, quinoa	A'Bunadh Seeds, Eagle Creek Farms, Heritage Harvest Seeds, Little Beau Seed Co., Moonglow Gardens, No Coast Seeds, Prairie Garden Seeds, Wildrose Heritage Seed Company	Screening/ observation trials, showcase garden
Ontario	Fertile Ground Farm	Amaranth, beet, cabbage, carrot, cucumber, eggplant, fennel, ground cherry, hot pepper, kale, lettuce, luffa, melon, okra, pole bean, potato, shelling pea, snow pea, sugar snap pea, sweet pepper, tatsoi, tomatillo, tomato, turnip, watermelon, winter squash	Adaptive Seeds, Angie Koch, Annapolis Seeds, BC Eco Seed Co-op, Bingenheimer Saatgut, Bob Wildfong, Carrot Improvement for Organic Agriculture, Centre for Sustainable Food Systems at the University of British Columbia Farm, Commonwealth Seeds, Dan Brisebois, David Catzel, Fruition Seeds, Gaia Organic Seeds, Greta's Family Gardens, Seeds of Diversity's Ground Cherry Breeding Project, Hawthorn Farm Organic Seeds, Heron Breen, High Mowing Organic Seeds, Isabelle Spence-Legault, Johann Kleinsasser, Johnny's Selected Seeds, Kitchen Table Seed House, La Societe des Plantes, Les Jardins de l'écoumène, Mimosa Breeding and Research Hillsburgh, Orchard Hill Farm, Organic Seed Alliance, Rare Charitable Research Reserve, Rebecca Ivanoff, Richters Herbs (grown by a supplier in the Midwest), Rony Eleazar Lec Ajcot, Saanich Organics, Sage Garden, Salt Spring Seeds, Seeds of Diversity Canada, Seven Seeds Farm, The Secret Garden Seeds, Tourne-Sol Cooperative Farm, UJAMAA SEEDS, Uprising Seeds, Wild Garden Seed, Wildrose Heritage Seed Company, Yonder Hill Farm	Screening/ observation trials, showcase garden, variety trial

(Table A1 continues on the next page)

Region	Demo Site	Crops grown	Seed providers	Types of Plots
Quebec	Bishop's University	Bean, bok choy, carrot, chicoree, cucumber, eggplant, flowers, kale, lettuce, garlic, melon, mustard, pea, pepper, rutabaga, turnip, winter squash	Adaptive Seeds, Atlantic Canada Regional Seed Bank, Caroline Poirier, Claire Luby, David Catzel, Experimental Farm Network, Carrot Improvement for Organic Agriculture, Centre for Sustainable Food Systems at the University of British Columbia Farm, Hawthorn Farm Organic Seeds, High Mowing Organic Seeds, Hugo Martorell, Irwin Goldman, Jardins de la Gaillarde, Jean-Francois Daoust, Johnny's Selected Seeds, La Société des Plantes, Terre Promise, Organic Seed Alliance, Prairie Garden Seeds, Ferme Co-operative Tourne-sol, Ferme Val-aux-Vents, Row 7 Seed Company, Seeds of Diversity, Semences du patrimoine, Siskiyou Seeds, Solstice Seeds, Veseys Seeds, Wild Garden Seed	Plant bleeding plot, screening/ observation trial, variety trial, vegetable seed production plot
	La Radicule			
	Patchwork Farms			
Maritimes (New Brunswick, Prince Edward Island, Nova Scotia)	Legacy Garden	Bean, beet, broccoli, brussel sprouts, cabbage, carrot, cauliflower, chard, cucumber, eggplant, kale, lettuce, melon, onion, pea, parsnip, pepper, pumpkin, rhubarb, rutabaga, summer savory, summer squash, tomato, winter squash	Agriculture and Agri-Food Canada, Annapolis Seeds, Atlantic Pepper Seeds, Cochrane Family Seeds, Emmerdale Eden Farm, Ferme Spiral Farm, Fundy Farms, Hope Seeds, Lorna and Brian McMaster, Mapple Farm, Nikian Farm, Northwind Farm, Perfectly Perennial Herbs and Seeds, Revival Seeds, Stormhaven Farm and Studios, Twisted Brook Farm, Whispering Hill Farm, Wysmykal Farm, Yonder Hill Farm	Screening/ observation trials, showcase garden

TABLE A2

Field Crop Demonstration Sites

Full list field crops grown at demonstration sites, split up by region.

Region	Demonstration Site	Crops grown	Types of Plots
British Columbia	Kwantlen Polytechnic University	Kernza, oat, wheat	Showcase garden
Prairies (Alberta, Saskatchewan, Manitoba)	Mackenzie Applied Research Association	PPB oat, PPB wheat	Plant breeding plot, variety trials
	Moose Creek Organic Farm		
	Organic farm in Libau		
	Parkland Crop Diversification Foundation		
	University of Alberta		
	University of Manitoba		
Ontario	Ironwood Organics	Barley, PPB oat, regionally-adapted wheat	Plant breeding plot, showcase garden
Quebec	Bishop's University	Kernza, PPB oat, PPB wheat, quinoa, switchgrass, vetch	Bulking up grain plot, plant breeding plot, variety trials
	Ferme Céréalière Paquet		
	Vital Potvin and Club de gestion des sols du Témiscouata		
Maritimes (New Brunswick, Prince Edward Island, Nova Scotia)	Charlottetown Research and Development Centre	Paddy rice, PPB oat	Showcase garden, variety trial
	Nikian Gardens		

PPB plots at the University of Alberta.
Photo credit: @talonstokesphotography.

APPENDIX B.

Participatory Plant Breeding (PPB) Field Crop Trial Results

TABLE B1

PPB Wheat Variety Trial Yield Data (2020-2022) Adapted From Carkner (2024). Estimate means (Lsmeans) and analysis of variance (ANOVA) comparing grain yield (kg/ha) of 25 spring wheat farmer genotypes and 6 check varieties grown in 12 organic environments in 2020, 2021, and 2022.

Check varieties were AAC Brandon, Vesper, AAC Tradition, Zealand, Jake, and CDC Kernen. The asterisks indicate the significance level of the effect of variety on yield based on ANOVA analysis: *** p<0.001, ** p<0.01, * p<0.05. Different letters indicate a significant difference between varieties according to Tukey's honest significant difference (HSD) analysis, with the letter "a" indicating the greatest value, and so on.

Genotype	Genotype Mean***	Carman 2020	Carman 2021***	Carman 2022*	Edmonton 2021***	Edmonton 2022***	Libau 2020	Libau 2021	Libau 2022	Oxbow 2021	Oxbow 2022	Roblin 2021	Roblin 2022
BJ08ACG	2303ef	2810	1619abcdefgh	2672defgh	2742efg	4933bcde	1385	2142	2458	2187	887	772	3053
BJ08AIG	2387abcdef	3304	1260jk	3137abcdefgh	3042bcde	4862bcdefg	1574	1909	3072	2038	1219	636	2595
BJ10AKB	2364bcdef	3059	1593bcdefghi	3222abcdefg	2755defg	4716defgh	1433	1986	3101	2174	907	703	2726
BJ10ASC	2242fg	3210	1365hijk	3119abcdefgh	1979jk	4748cdefgh	1621	1686	2621	1636	1138	1010	2779
BJ11ACG	2284ef	3304	1465defghijk	2845cdefgh	2483ghi	4745cdefgh	1471	1753	3127	1809	978	714	2758
BJ11AKB	2344def	3208	1563bcdefghi	2329h	3490a	4916bcde	1327	2021	2626	2301	836	596	2899
BJ11ASC	2353cdef	3041	1519cdefghi	2775cdefgh	2573fghi	5090abcd	1424	1954	3089	2138	953	609	3077
BJ13GW	2497abcd	3383	1852a	3245abcdefg	2885bcdef	5081abcd	1198	1992	3127	2275	1249	440	3238
BJ13HRE	2394abcdef	3388	1720abcd	2962bcdefgh	3081bc	4497fgh	1518	2134	2878	2128	1151	432	2839
BJ15GW	2320ef	3178	1534cdefghi	2996bcdefgh	2762cdef	4719defgh	1347	2017	2919	1992	964	656	2758
BJ15AGM	2359cdef	3622	1509cdefghij	3032bcdefgh	2865bcdef	4666efgh	1221	1787	2712	2151	1193	607	2945
BL22ASW	2354cdef	2872	1603abcdefghi	3373abcd	2579fgh	5110abc	1442	1999	2571	2236	1093	738	2615

(Table B1 continues on the next page)

Genotype	Genotype Mean****	Carman 2020	Carman 2021****	Carman 2022*	Edmonton 2021*****	Edmonton 2022****	Libau 2020	Libau 2021	Libau 2022	Oxbow 2021	Oxbow 2022	Roblin 2021	Roblin 2022
BL23AS	2448abcde	3282	1455efghijk	3864a	2655fg	4721defgh	1556	1892	2838	2085	1483	866	2679
BL23JM	2393abcdef	3598	1385ghijk	3585abc	2595fgh	4868bcdef	1272	1757	2703	1981	1219	697	3044
BL28JM	2333def	3010	1651abcdef	3186abcdefg	2763cdef	4569efgh	1413	2057	2925	2166	1002	883	2357
BL23AS	2448abcde	3282	1455efghijk	3864a	2655fg	4721defgh	1556	1892	2838	2085	1483	866	2679
BL28TM	2406abcdef	3443	1488defghij	3752ab	2818cdef	4508fgh	1630	1945	3090	2061	1244	540	2360
BL28WM	2268f	2869	1520cdefghi	2478gh	2434ghi	4709defgh	1508	2157	2913	2168	1137	866	2456
BL34AJM	2274f	2916	1619abcdefgh	2568defgh	2683fg	4836bcdefg	1585	1896	3403	1690	856	547	2702
BL34AWM	2363bcdef	3180	1641abcdefg	3203abcdefg	2689fg	4941bcde	1286	1875	2815	1773	1458	937	2560
BL34SW	2521abc	3731	1684abcdef	3258abcdefg	2565fghi	4944bcde	1494	2116	3374	2118	1343	792	2829
BL39AWM	2406abcdef	4035	1618abcdefgh	3189abcdefg	2657fg	4811bcdefg	1396	1828	3083	1590	1161	898	2611
BL41AAS	2304ef	3201	1686abcde	3356abcde	2254ij	4501fgh	1290	1954	3033	1990	1026	781	2583
BL41AMS	2303ef	3253	1576bcdefghi	3035bcdefgh	1862kl	4930bcde	1278	1755	3023	2370	1109	927	2524
BL43CTM	2541a	3339	1717abcd	2998bcdefgh	3162b	5362a	1467	2160	3215	1969	1319	719	3067
PWA10BLD	2064h	2622	1353ijk	2553efgh	2703fg	4371h	1297	1864	2445	1825	981	485	2269
AAC Brandon	2284ef	2668	1427fghijk	2285h	2793cdef	5371a	1226	1892	2728	2497	681	977	2860
Vesper	2529ab	3951	1666abcdef	3323abcdef	3070bcd	4919bcde	1435	1994	3230	2128	1260	668	2709
AAC Tradition	2276f	2950	1801ab	2618defgh	2321hi	5463a	1395	2086	2496	2145	961	663	2419
Zealand	2310ef	3065	1748abc	2515fgh	3038bcde	5153ab	1399	1893	2781	2272	848	292	2718
Jake	2098gh	2486	1213k	2748defgh	1588l	4478gh	1235	1721	2659	1927	1027	935	3162
CDC Kernen	2317ef	3106	1636abcdefg	2743defgh	3171ab	4882bcdef	1327	1892	2677	2051	852	803	2683

TABLE B2

PPB Wheat Variety Trial Height Data (2020-2022) Adapted From Carkner (2024). Estimate means (Lsmeans) and analysis of variance (ANOVA) comparing grain height (cm) of 25 spring wheat farmer genotypes and 6 check varieties grown in 12 organic environments in 2020, 2021, and 2022.

Check varieties were AAC Brandon, Vesper, AAC Tradition, Zealand, Jake, and CDC Kernen. The asterisks indicate the significance level of the effect of variety on yield based on ANOVA analysis: *** p<0.001, ** p<0.01, * p<0.05. Different letters indicate a significant difference between varieties according to Tukey's honest significant difference (HSD) analysis, with the letter "a" indicating the greatest value, and so on.

Genotype	Genotype Mean ***	Carman 2020 ***	Carman 2021 ***	Carman 2022 ***	Edmonton 2021	Edmonton 2022 ***	Libau 2020 ***	Libau 2021 ***	Libau 2022 ***	Oxbow 2021 ***	Oxbow 2022	Roblin 2021	Roblin 2022 ***
BJ08ACG	81bcde	86bcdefgh	65bcde	101cdef	75	88cdef	70abcdef	78bcdefghij	101ab	71ghij	85	48	83ghij
BJ08AIG	83ab	91abcd	69abc	113a	72	97a	67abcdefg	81abcdef	95cdefgh	78ab	86	48	95ab
BJ10AKB	84a	92abc	69abc	111abc	78	93abcde	74a	85a	97abcdef	73cdefgh	83	52	94abc
BJ10ASC	79defgh	83efghij	67bcd	105abcde	72	87cdef	72abc	74ghijklm	94defgh	72efghij	82	53	87defghi
BJ11ACG	83a	96a	72abc	109abc	78	94abc	70abcdef	80abcdefgh	100abcd	74bcdefgh	83	48	96a
BJ11AKB	79defg	88abcdefg	64cde	101cdef	73	85fg	65cdefg	77defghijkl	98abcde	72efghij	83	47	87cdefghi
BJ11ASC	84a	92ab	67abcd	113ab	73	96a	68abcdefg	85a	102a	78abc	84	46	90abcdefg
BJ13GW	79efghi	83defghij	69abc	103abcdef	68	87cdef	65cdefgh	77defghijk	93efghi	72efghij	80	44	88bcdefghi
BJ13HRE	83ab	90abcde	70abc	111abc	73	93abcde	72abcd	84abc	100abc	76abcdef	86	45	93abcde
BJ15GW	83ab	91abcd	69abc	107abcd	73	94abc	71abcde	85ab	99abcde	76abcde	82	47	94abcd
BJ15AGM	81bcd	92abc	67bcd	110abc	74	92abcdef	65cdefghi	80abcdefg	98abcde	77abcd	82	44	93abcde
BL22ASW	77ij	81hijk	60de	105abcde	68	89cdef	62ghij	75efghijkl	88hij	71fghij	82	47	87efghi

(Table B2 continues on the next page)

Genotype	Genotype Mean ***	Carman 2020 ***	Carman 2021 ***	Carman 2022 ***	Edmonton 2021	Edmonton 2022 ***	Libau 2020 ***	Libau 2021 ***	Libau 2022 ***	Oxbow 2021 ***	Oxbow 2022	Roblin 2021	Roblin 2022 ***
BL23AS	78fghi	82fghijk	64cde	105abcde	72	88cdef	66bcdefg	73hijklm	88hij	71efghij	80	50	78jk
BL23JM	77hij	82hijk	65bcde	106abcde	69	89bcdef	56jk	73hijklm	87ij	70ghij	83	52	83hij
BL28JM	84a	90abcde	75a	109abc	72	92abcdef	74ab	83abcd	101ab	79a	86	50	94abc
BL28TM	80cdef	87bcdefgh	66bcd	109abc	78	92abcdef	71abcdef	79abcdefghi	95bcdefg	73cdefgh	77	47	96a
BL28WM	81cdef	86cdefgh	70abc	101cdef	70	92abcdef	65cdefgh	84ab	97abcdef	74bcdefg	83	47	94abc
BL34AJM	81cde	88bcdefg	70abc	107abcd	72	92abcdef	74ab	79abcdefghi	97abcdef	70ghij	88	46	91abcdef
BL34AWM	82abc	89bcdef	68abc	109abc	68	97a	66cdefg	72jklmn	96bcdefg	69hijk	88	48	93abcde
BL34SW	81bcde	88bcdefg	68abcd	109abcd	81	91abcdef	64defghij	79abcdefghi	95bcdefg	72efghij	81	50	87defghi
BL39AWM	81cde	88bcdefg	73ab	106abcde	73	89cdef	64efghij	76efghijkl	97abcdef	73cdefgh	80	51	93abcde
BL41AAS	79efghi	85cdefghi	65cde	101cdef	67	93abcd	66cdefg	77cdefghij	89ghij	74bcdefgh	83	45	84fghij
BL41AMS	81cde	82ghijk	67abcd	107abcd	74	90abcdef	65cdefgh	76efghijkl	90ghij	78ab	85	59	84fghij
BL43CTM	78efghi	77jk	69abc	102bcdef	72	91abcdef	63fghij	78bcdefghij	92fghi	68ijk	87	47	91abcdefg
PWA10BLD	80cdefg	87bcdefgh	68abcd	107abcd	75	86efg	69abcdef	82abcde	97abcdef	70ghij	78	48	81ijk
AAC Brandon	67m	70l	52f	81g	65	71h	50k	76n	72l	66jk	80	45	69l
Vesper	74kl	82fghijk	57ef	102cdef	70	87cdef	58hijk	70lmn	87ij	67jk	82	43	82hij
AAC Tradition	72l	75kl	65bcde	93f	62	79g	53k	68mn	79k	64k	81	43	75kl
Zealand	78ghi	82fghijk	68abc	98def	69	96ab	62ghij	72ijklm	90ghij	74bcdefgh	83	44	89bcdefgh
Jake	75jk	78ijk	57ef	96ef	69	89cdef	57ijk	71klmn	84jk	69ghij	84	52	82hij
CDC Kernen	78ghi	84defghi	66bcd	106abcde	72	87def	67bcdefg	75fghijklm	90ghij	72defghi	82	48	83ghij

TABLE B3

PPB Wheat Variety Trial Yield Data (2022-2023) ANOVA and pairwise comparisons for average yield (kg/ha) of farmer-bred PPB and check varieties of wheat in 2022 and 2023 at UofA and MARA.

Check varieties were Zealand and Vesper. Selection region denotes the area where that farmer wheat lines were grown and selected in. "N/A" denotes not available. The asterisks indicate the significance level of the effect of variety based on ANOVA analysis: *** p<0.001, ** p<0.01, * p<0.05, ^ p=0.05. Different letters indicate a significant difference between varieties according to Tukey's honest significant difference (HSD) analysis, with the letter "a" indicating the greatest value, and so on.

Variety	Selection region	Average yield	UofA 2022	UofA 2023	MARA 2022	MARA 2023
			Yield***	Yield^	Yield*	Yield
BL23AS	Wood Mountain, SK	4277.3a	4721.7abc	5003.7ab	5835.9ab	3057.1a
BJ13HRE	Libau, MB	4390.5a	4497.7c	4684.7ab	5827.6ab	3634.0a
Zealand	N/A	4408.1a	5153.7abc	4747.0ab	4937.7ab	4092.1a
BL34SW	Swift Current, SK	4481.7a	4944.7abc	4947.3ab	6074.3ab	3629.5a
BL34AJM	Fort Vermilion, AB	4594.4a	4836.7abc	5003.7ab	6583.2ab	3550.1a
BJ11AKB	Carman, MB	4603.1a	4916.0abc	4979.3ab	5154.1ab	4369.3a
BL28WM	Sturgeon County, AB	4760.9a	4709.7abc	4680.7ab	6552.7ab	4812.2a
BJ15AGM	Kleefeld, MB	4888.4a	4666.0abc	4776.3ab	6753.7ab	4791.2a
BJ08AIG	Brandon, MB	4898a	4862.7abc	4965.0ab	6726.8ab	4436.9a
Vesper	N/A	5067.8a	4919.7abc	5097.7ab	7089.4ab	4633.0a
BL28JM	Fort Vermilion, AB	5071.0a	4570.0bc	5156.0ab	7525.6ab	4659.6a
BL43CTM	Altona, MB	5157.4a	5362.3ab	5034.3ab	7251.2ab	4498.8a
BL28TM	Altona, MB	5183.4a	4508.7c	4772.3ab	7905.8ab	5049.2a
BJ13GW	Metcalfe, ON	5257.3a	5081.7abc	5172.3ab	7265.4ab	5223.3a

TABLE B4

PPB Wheat Variety Trial Yield Data (2022-2023) ANOVA and pairwise comparisons for average yield (kg/h) of farmer-bred PPB and check varieties of wheat in 2022 and 2023 at UofA and MARA.

Only 14 varieties were trialled at both sites. ANOVA for average yield was only done on varieties trialled at both sites. Check varieties were AAC Brandon, CDC Kernen, AAC Tradition, Zealand, Jake, and Vesper. Selection region denotes the area where that farmer wheat lines were grown and selected in. "N/A" denotes not available. Asterisks indicate the significance level of the effect of variety based on ANOVA analysis: *** p<0.001, ** p<0.01, * p<0.05, ^ p=0.05. Different letters indicate a significant difference between varieties according to Tukey's honest significant difference (HSD) analysis, with the letter "a" indicating the greatest value, and so on.

Variety	Selection region	Average yield	UofA 2022	UofA 2023	MARA 2022	MARA 2023
			Yield***	Yield^	Yield*	Yield
PWA10BLD	Les Cèdres, QC	4510.4	4371.0c	4649.7b		
AAC Brandon	N/A	5179.4	5372.0ab	4986.7ab		
BJ08ACG	Lethbridge, AB	5275.5	4933.7abc	5617.3ab		
CDC Kernen	N/A	4949.9	4882.0abc	5017.7ab		
BJ11ACG	Lethbridge, AB	4860.0	4746.3abc	4973.7ab		
BJ15GW	Metcalfe, ON	4735.4	4719.7abc	4751.0ab		
BJ11AKB	Carman, MB	4854.7a	4916.0abc	4979.3ab	5154.1ab	4369.3a
BJ11ASC	Melita, MB	5076.3	5090.3abc	5062.3ab		
BJ13GW	Metcalfe, ON	5685.7a	5081.7abc	5172.3ab	7265.4ab	5223.3a
BJ13HRE	Libau, MB	4661.0a	4497.7c	4684.7ab	5827.6ab	3634.0a
AAC Tradition	N/A	5638.0	5463.3a	5812.7a		
BJ10AKB	Carman, MB	4948.9	4716.7abc	5181.0ab		
BJ15AGM	Kleefeld, MB	5246.8a	4666.0abc	4776.3ab	6753.7ab	4791.2a
BL28JM	Fort Vermilion, AB	5477.8a	4570.0bc	5156.0ab	7525.6ab	4659.6a
BL34AWM	Sturgeon County, AB	4897.2	4942.0abc	4852.3ab		
BL39AWM	Sturgeon County, AB	4980.7	4811.3abc	5150.0ab		
BL34AJM	Fort Vermilion, AB	4993.4a	4836.7abc	5003.7ab	6583.2ab	3550.1a

(Table B4 continues on the next page)

Variety	Selection region	Average yield	UofA 2022	UofA 2023	MARA 2022	MARA 2023
			Yield***	Yield^	Yield*	Yield
BJ08AIG	Brandon, MB	5247.9a	4862.7abc	4965.0ab	6726.8ab	4436.9a
BJ10ASC	Melita, MB	4701.5	4748.7abc	4654.3b		
BL34SW	Swift Current, SK	4899.0a	4944.7abc	4947.3ab	6074.3ab	3629.5a
BL43CTM	Altona, MB	5536.7a	5362.3ab	5034.3ab	7251.2ab	4498.8a
BL28WM	Sturgeon County, AB	5188.8a	4709.7abc	4680.7ab	6552.7ab	4812.2a
BL28TM	Altona, MB	5559.0a	4508.7c	4772.3ab	7905.8a	5049.2a
Zealand	N/A	4732.6a	5153.7abc	4747.0ab	4937.7b	4092.1a
Jake	N/A	4583.7	4478.7c	4688.7ab		
BL22ASW	Swift Current, SK	4906.7	5110.0abc	4703.3ab		
BL23AS	Wood Mountain, SK	4654.6a	4721.7abc	5003.7ab	5835.9ab	3057.1a
BL23JM	Fort Vermilion, AB	4826.9	4868.7abc	4785.0ab		
BL41AAS	Wood Mountain, SK	4653.8	4501.3c	4806.3ab		
BL41AMS	Glentworth, SK	4935.9	4931.0abc	4940.7ab		
Vesper	N/A	5435.0a	4919.7abc	5097.7ab	7089.4ab	4633.0a

TABLE B5

PPB Wheat Variety Trial Grain Height Data (2022-2023) ANOVA and pairwise comparisons on average height (cm) of farmer-bred PPB and check varieties of wheat in 2022 and 2023 at UofA and MARA.

Only 14 varieties were trialled at both sites. Check varieties were AAC Brandon, CDC Kernen, AAC Tradition, Zealand, Jake, and Vesper. Selection region denotes the area where that farmer wheat lines were grown and selected in. "N/A" denotes not available. Asterisks indicate the significance level of the effect of variety based on ANOVA analysis: *** p<0.001, ** p<0.01, * p<0.05, ^ p=0.05. Different letters indicate a significant difference between varieties according to Tukey's honest significant difference (HSD) analysis, with the letter "a" indicating the greatest value, and so on.

Variety	Selection region	Average height	UofA 2022	UofA 2023	MARA 2022	MARA 2023
			Height***	Height***	Height***	Height
PWA10BLD	Les Cèdres, QC	92.1	95.3b	88.7efg		
AAC Brandon	N/A	78.0	80.7c	75.3g		
BJ08ACG	Lethbridge, AB	98.0	98.0b	98.0abcdef		
CDC Kernen	N/A	95.0	96.0b	94.0abcdef		
BJ11ACG	Lethbridge, AB	102.0	103.3a	100.7abcdef		
BJ15GW	Metcalfe, ON	101.3	103.3a	99.3abcdef		
BJ11AKB	Carman, MB	93.0	94.7b	96.0abcdef	87.5 a	93.9 ab
BJ11ASC	Melita, MB	104.0	106.0a	102.0abcde		
BJ13GW	Metcalfe, ON	96.6	96.7b	98.0abcdef	95.9 ab	95.7 ab
BJ13HRE	Libau, MB	97.8	102.0ab	106.7a	91.0 a	91.5 ab
AAC Tradition	N/A	88.0	88.7bc	87.3fg		
BJ10AKB	Carman, MB	102.4	102.0ab	102.7abcd		
BJ15AGM	Kleefeld, MB	97.8	101.3ab	105.3ab	88.9 a	95.7 ab
BL28JM	Fort Vermilion, AB	100.1	101.3ab	104.0abc	96.5 a	98.5 a
BL34AWM	Sturgeon County, AB	100.4	106.0a	94.7abcdef		
BL39AWM	Sturgeon County, AB	97.0	98.0b	96.0abcdef		
BL34AJM	Fort Vermilion, AB	94.1	101.3ab	102.7abcd	86.1 a	86.3 ab

(Table B5 continues on the next page)

Variety	Selection region	Average yield	UofA 2022	UofA 2023	MARA 2022	MARA 2023
			Yield***	Yield^	Yield*	Yield
BJ08AIG	Brandon, MB	99.6	106.0a	106.0ab	94.6 a	91.8 ab
BJ10ASC	Melita, MB	93.7	96.7b	90.7cdef		
BL34SW	Swift Current, SK	92.4	100.0ab	99.3abcdef	88.0 a	82.1 ab
BL43CTM	Altona, MB	90.5	100.7ab	92.7bcdef	89.5 a	79.1 b
BL28WM	Sturgeon County, AB	97.2	101.3ab	101.3abcde	90.3 a	96.0 ab
BL28TM	Altona, MB	169.1	387.7a	100.0abcdef	90.3 a	98.4 a
Zealand	N/A	91.7	105.3a	92.7bcdef	83.1 a	85.5 ab
Jake	N/A	96.0	98.0b	94.0abcdef		
BL22ASW	Swift Current, SK	93.4	98.0b	88.7efg		
BL23AS	Wood Mountain, SK	88.4	97.3b	96.0abcdef	81.8 a	78.4 b
BL23JM	Fort Vermilion, AB	95.7	98.7b	92.7bcdef		
BL41AAS	Wood Mountain, SK	98.0	102.7a	93.3abcdef		
BL41AMS	Glentworth, SK	101.0	99.3b	102.7abcd		
Vesper	N/A	91.4	96.7b	89.3def	84.1 a	95.4 ab

TABLE B6

PPB Oat Variety Trial Yield and Height Data (2022-2023)
The effect of variety on average height (cm) and yield (kg/ha) of farmer-bred PPB and check varieties of oats trialled at MARA in 2022 and 2023.

Check varieties were AC Morgan and AC Kongsore. Selection region denotes the area where that farmer oat lines were grown and selected in. "N/A" denotes not available. The asterisks indicate the significance level of the effect of variety based on ANOVA analysis: *** p<0.001, ** p<0.01, * p<0.05. Different letters indicate a significant difference between varieties according to Tukey's honest significant difference (HSD) analysis, with the letter "a" indicating the greatest value, and so on.

Variety	Selection region	Average height***	Height 2022*	Height 2023***	Average yield	Yield 2022*	Yield 2023**
11P2216FB	Fort Vermilion, AB	96.3bcd	93.0a	99.6abc	5100.4a	5256.2a	6023.9abc
11P1315IG	Brandon, MB	102.2abc	105.8a	98.7abc	5037.5a	4218.4ab	5856.6abc
09P0215TM	Altona, MB	105.2ab	105.4a	105.1ab	5582.2a	4418.1ab	6746.3a
11P1716JM	Fort Vermilion, AB	102.1abc	105.4a	98.8abc	5272.1a	4756.1ab	5788.1abc
11P1916JM	Fort Vermilion, AB	107.0a	102.4a	111.7a	5821.3a	4768.3ab	6874.2a
11P0515ML	Vonda, SK	89.1d	90.5a	87.7c	5521.0a	4866.7ab	6175.3abc
11P1716FB	Fort Vermilion, AB	100.9abc	100.8a	101.1abc	5402.8a	4674.1ab	6131.5abc
11P1916FB	Fort Vermilion, AB	94.5bcd	99.0a	90.1c	5714.3a	5256.2ab	6172.2abc
11P2015ML	Vonda, SK	95.3bcd	98.3a	92.3bc	5110.7a	4476.4ab	5745.0abc
11P1315ML	Vonda, SK	96.6abcd	97.0a	96.2bc	4983.5a	4252.5ab	5714.5abc
11P0115AS	Wood Mountain, SK	92.1cd	94.9a	89.3c	4847.2a	4259.6ab	5434.8abc
AC Morgan	N/A	93.0cd	95.0a	91.0c	5454.6a	4722.7b	6186.4abc
AC Kongsore	N/A	100.7abc	102.0a	99.4abc	5464.7a	4246.8ab	6682.6ab
11P0716KS	Grandview, MB	98.5abcd	100.1a	96.9bc	4567.5a	3809.9ab	5325.2c

Summer squash growing at the Fertile Ground Farm in Ontario. *Photo credit: Angie Koch, Janine Stanic, and Nikola Barsoum.*

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